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## AGE CHANGES IN THE PUBIC BONE<sup>1</sup>

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## II. AGE CHANGES IN THE PUBIC BONE OF THE MALE NEGRO-WHITE HYBRID

### INTRODUCTION—THE MALE WHITE OS PUBIS

In the first contribution to this subject (7) I discussed at some length the age changes occurring in the pubic bone of the male White after the eighteenth year. In that communication I explained that individuals of one human stock and sex were taken in order to obtain, so far as possible, a standard by which comparisons could be made with other stocks, with the female sex, and with Primates in general. The observations showed that there is a definite metamorphosis going on in the pubic bone throughout life, and that this metamorphosis has a fairly precise age-relationship which I summarized in the following manner:

Age 18-19. Phase 1:—Typical adolescent ridge and furrow formation with no sign of margins and no ventral bevelling.

<sup>1</sup>For Part I see No. 3, Vol. III, of this Journal.

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Age 20-21. Phase 2:—Foreshadowing of ventral bevelling with slight indication of dorsal margin.

Age 22-24. Phase 3:—Progressive obliteration of ridge and furrow system with increasing definition of dorsal margin and commencement of ventral rarefaction (bevelling).

Age 25-26. Phase 4:—Completion of definite dorsal margin, rapid increase of ventral rarefaction and commencing delimitation of lower extremity.

Age 27-30. Phase 5:—Commencing formation of upper extremity with increasing definition of lower extremity and possibly sporadic attempts at formation of ventral rampart.

Age 30-35. Phase 6:—Development and practical completion of ventral rampart with increasing definition of extremities.

Age 35-39. Phase 7:—Changes in symphyseal face and ventral aspect of pubis consequent upon diminishing activity, accompanied by bony outgrowths into pelvic attachments of tendons and ligaments.

Age 39-44. Phase 8:—Smoothness and inactivity of symphyseal face and ventral aspect of pubis. Oval outline and extremities clearly defined but no "rim" formation or lipping.

Age 45-50. Phase 9:—Development of "rim" on symphyseal face with lipping of dorsal and ventral margins.

Age 50 and upwards. Phase 10:—Erosion of and erratic, possibly pathological osteophytic growth on symphyseal face with breaking down of ventral margin.

It has also been shown that the age-relationship of the metamorphosis is affected by local anomalies in the pubic bone, by certain diseases or rather by the disorganization of the functions of certain glands and to a smaller extent by undetermined individual factors. In occasional cases the metamorphosis remains incomplete throughout life as regards the ventral margin and upper extremity of the symphyseal face. Whereas there is usually practical harmony in the age relationships of various parts of the skeleton, occasionally the stage of bone-change in the os pubis is at variance with that of other bones. The symphyseal face has practically reached its adult dimensions at puberty so far as the cartilages go but the bony dimensions cannot be accurately measured until phase 6 is completed which occurs at about the age of thirty-five. After the age of eighteen



there is practically no actual growth of bone at the symphysis and certainly none after the twenty-first year.

In the ensuing pages it will be taken for granted that the reader is conversant with the features of the male White os pubis. I shall therefore proceed immediately to a discussion of the bone in the male Negroid without repeating all the details previously given.

THE OS PUBIS OF THE NEGRO-WHITE HYBRID MALE  
TYPICAL METAMORPHOSIS

There is no large series available of pure African material or indeed of any other non-White stock with accurate information as regards age. Hence we are driven to use American Negro-White hybrid material for comparison with the observations upon the male White skeleton. Actually this is not of practical disadvantage because the differences between the White and Negro stocks are sufficiently marked to be picked out even in hybrid material. As evidence of this fact the recent papers by Schultz upon the external nose in Whites and Negro-White hybrids may be cited (5, 6). Furthermore, in the course of present studies one is convinced that the negroid type of pelvis is retained in the hybrid population. Since then in morphological features the Negro-hybrid pelvis is distinctly negroid one must expect that the features of growth and metamorphosis of the pelvic bones will also bear testimony to the negroid origin.

The material used in the present study includes quite varied racial admixtures from the very dark to the quadroon. Samples of the skin of most are retained in the laboratory but the relation of these samples to Davenport's color mixtures (3) gives us no help in the present connection. It is noticeable that the various skeletal features do not go hand in hand with the colorimetric values of the skin. During the influx of Negroes from the south which has taken place in the past few years we have noticed that the southern Negro-hybrid is more distinctively negroid in external features than that of the north. From a consideration of all these factors one might anticipate in the American Negro-hybrid a greater or more erratic individual deviation from the typical age-relationship, always presupposing that there is an age-relationship typical for the Negro and differing from the standard established for the White. In the following pages we

shall see what relation such a hypothesis has to actual fact.

Our Negro-hybrid male material of known age comprises ninety pelves the majority of which, it will be observed, lies between the ages of seventeen and forty-five. Reference to Fig. 2 discloses the fact that the numbers are fairly evenly distributed along this age period and the polygon is devoid of the striking upward leaps which characterize the polygon of ages of the male White material. We have therefore little inherent suggestion that there may be gross errors in the age records.

As illustrative of the condition of the pubic bone soon after puberty we take pelves Nos. 519, 695 and 721 of ages seventeen, eighteen and eighteen respectively (Figs. 3, 4). In all the iliac and ischial epiphyses are in process of uniting with the main mass of the bone; in No. 519 alone the epiphysis for the anterior inferior spine is still incompletely united on both sides.

The symphysial face of each exhibits the characteristic horizontal ridges and furrows, a little less pronounced perhaps in No. 721 than in the others. The greater relative massiveness of the upper ridges noted in the male White is not apparent here. In all the rugged symphysial face extends to include the pubic tubercle and no ossified epiphyses occur. As in the male White there is no indication of a dorsal delimiting margin although the symphysial face is sharply marked off from the dorsal and ventral aspects of the pubis by an abrupt change in surface appearance and bony texture. A similar though less abrupt change differentiates the symphysial face from the upper aspect of the pubis whereas the lower part of the face merges gradually into the more smoothly textured inferior pubic ramus. It is apparent then that there is no striking racial difference between the Negro-hybrid and the White in the immediate post-adolescent features of the pubic symphysis (Phase I).

In No. 693 (age eighteen) and Nos. 17 and 588 (age nineteen) (Figs. 5, 6) the ischial epiphyses are united except at their ramal portion, though the iliac epiphyses show no more complete union than in the last group. The symphysial faces of these are as already described, except that in Nos. 693 and 588 the pubic tubercle is completed and this without the assistance of an ossified epiphysis.

We have then among this material six specimens between the ages of seventeen and nineteen which display characters precisely similar

to those of the White male material of the same ages except that the ridges are of the same approximate dimensions throughout the symphysial face.

*First post-adolescent phase. Age 17-19:*—Symphysial surface rugged, traversed by horizontal ridges separated by well-marked grooves. No ossific (epiphysial) nodules fusing with the surface. No definite delimiting margin. No definition of extremities.

Skeletons 639 and 808 each of age twenty years, and 698 and 413 each of age twenty-two (Figs. 7, 8, 9) show features noted in the male White series as characteristic of the second post-adolescent phase. Both iliac and ischial epiphyses are united fully in all save 413, but Nos. 639 and 808 still exhibit plainly the junction lines of these epiphyses. This clear indication of the recent fusion remains for a short time only and is already invisible in No. 698. No. 413 shows incomplete union of the iliac epiphyses and non-union as yet of the ramal portions of the ischial epiphyses. In all these specimens a ridge appears linking up the hinder ends of the horizontal ridges and the grooves adjacent to this dorsal delimiting ridge are filling up with finely textured bone. The other notable feature is the beginning of the break-down of the ventral region of the surface to bring about the characteristic bevelling which will be so obvious in the next group.

As with the members of the same phase in the male White series the occurrence of bony epiphysial nodules is apparent at this stage. They are present already fused on both sides of No. 413. In these examples as in the previous series there is no difference in size between the upper and lower horizontal ridges.

This phase in the Negro-hybrid occurs at the same age as in the male White and is characterized by the same general features which may be presented in brief in the following manner.

*Second post-adolescent phase. Age 20-22:*—Symphysial surface still rugged, traversed by subequal horizontal ridges, the grooves between which are becoming filled near the dorsal limit, however, with a new formation of finely textured bone which begins to obscure the hinder extremities even of the horizontal ridges themselves. Dorsal delimiting margin begins to develop. Early ventral bevelling. Occurrence of a bony (epiphysial) nodule at the upper extremity of



the symphyseal face in some cases. No delimitation of extremities as yet.

As in the case of the White the next stage in development of the pubis is practically an intensified continuation of the processes already foreshadowed in the last. Nos. 366 and 703 of age twenty-two, 506 of age twenty-three, and 497 of age twenty-four fall into this group (Figs. 10, 11). The horizontal ridges and furrows are still more or less evident although the hinder extremities of the latter are well filled by the new bone formation. The dorsal margin and adjoining platform are quite apparent. In all except 497 the upper bony nodule is present although varying greatly in size. But the striking feature is the ventral bevelling. There is no indication as yet of the lower extremity. In all these examples except 506 the horizontal ridges probably have never been very strongly marked. We may define the stage thus:

*Third phase.* Age 22-24:—Symphyseal face shows progressive obliteration of horizontal ridges and furrows. Commencing formation of the dorsal platform or plateau. Occurrence of fusing bony (epiphysal) nodules. Dorsal margin becoming more defined. Ventral bevelling from rarefaction strongly marked. No delimitation of extremities.

Phase IV is very inadequately represented in the collection so far for the only example referable to this stage is No. 524 of age twenty-four (Fig. 12). The outstanding feature of the phase is the development of the lower extremity which in the specimen is in its early beginning. The dorsal margin is however complete and the dorsal platform extends about one-third of the distance to the ventral limit of the surface. The ventral bevelling is very well marked. The most notable feature of this specimen however cannot be seen on the illustration. On both sides the epiphysal line can be traced from the ramal extension of the ischial epiphysis into the lower extremity of the symphyseal face which therefore would seem to be a direct continuation of the ischial epiphysis. This is still better marked in two specimens to be described later, namely, Nos. 792 and 744. The continuation however is more apparent than real for the ramal epiphysis stops at the narrowed portion of the pubis immediately below the lower extremity of the symphyseal face. That the ventral ram-part and the upper nodule represent ossification in the morphological

plane of the ischial epiphysis is undoubtedly true and the tissue in which they all develop is the strip of connective tissue along the ventral and inferior margin of pubis and ischium. The present is not a suitable stage of the discussion for commenting upon the morphological significance of this relationship which will be dealt with in a later communication.

The outstanding features of the phase may however be stated.

In the time relationship the ages to be given for this phase are twenty-five and twenty-six. Since our single specimen shows only the very commencement of the lower extremity at twenty-four and already at twenty-seven the next phase is well under way there is not in the male Negro-hybrid series sufficient evidence to suggest that the age relationship of phase IV differs in the Negro-hybrid from that presented by the male White in which this phase corresponded to the twenty-fifth and twenty-sixth years of age.

*Phase four.* Age 25-26:—Ventral bevelled area greatly increased. Corresponding diminution of ridge and furrow formation. Complete definition of dorsal margin and increase of dorsal platform. Appearance of lower extremity.

Again as in the male Whites formation of the upper extremity follows rapidly upon that of the lower and into this formation an upper bony nodule may or may not enter. The examples presented by this collection are Nos. 379 and 802 of age twenty-seven, 658 of age twenty-eight, and 402 of age twenty-nine (Figs. 13, 14). In 802 and 658 the lower extremity is not very clearly defined and the upper extremity is beginning to be formed with the assistance of an epiphysial nodule. In 379 and 402 the lower extremity is much better defined but the upper is in much the same condition as in the other two although the bony nodule is very insignificant or altogether absent. The ventral bevelling is well developed and there is no sporadic attempt at formation of a ventral rampart except in 802. We therefore group these in the following manner.

*Fifth phase.* Age 27-29:—Little or no change in symphyseal face except for occasional attempts at formation of ventral rampart. Increasing definition of lower extremity and dorsal margin. Commencing formation of upper extremity with or without the intervention of an epiphysial nodule.

There are twelve typical specimens (Figs. 15-19) belonging to



the next stage of development the characteristic feature of which is the formation and completion or approximate completion of the ventral rampart by which the classic oval outline of the symphyseal face is brought about. These specimens are, Nos. 259, 563, 568 and 569 of age twenty-nine; Nos. 343, 435 and 598 of age thirty; No. 486 of age thirty-two; Nos. 290 and 596 of age thirty-three; No. 677 of age thirty-four; No. 451 of age thirty-five.

As in the case of the male Whites age discrimination becomes somewhat more difficult from this period on for we are dealing with relatively minor details. The same general considerations also hold. The individuality of the upper osseous nodule becomes merged into the main mass of bone and the speed of formation of the upper extremity varies greatly; indeed it may not be completed. The same is true of the ventral rampart so that, when a hiatus does occur it usually lies in the upper third of the ventral margin. In some specimens the lower extremity is well defined before the ventral rampart is completed, in others the reverse is the case. One must therefore carefully weigh the evidence submitted by both the lower extremity and the ventral rampart before deciding upon the age indication. In all the examples of age twenty-nine the formation of the ventral rampart has progressed apace whereas the definition of the lower extremity has lagged to some extent. Especially is this true of No. 568.

All the other specimens show a more regular arrangement with the lower extremity becoming progressively well defined in advance of the growing ventral rampart. There is perhaps even some slight retardation in No. 486. In all the pelves however the vertical and antero-posterior diameters of the symphyseal face can be stated with assurance. These measurements could not be given with the same exactitude in previous series.

The building up of the ventral rampart occurs in the same manner as in the male White, namely either by the linkage of independent bony nodules with the upper and lower extremities or by the gradual throwing up of a continuous narrow mound of bone on the greatly rarefied ventral strip. In either case the rarefied bone remains without change on both symphyseal and ventral sides of the rampart and in this respect the ventral margin differs absolutely from the dorsal which carries with it the formation of the dorsal platform.

At this stage as in the White pelvis there is no lipping of the symphyseal margins such as one meets with in older bones.

Nos. 677 and 451 fall rather outside the limits of the group for the Negro-hybrid. This becomes more evident in consideration of the ensuing series. They were originally picked out as showing a very early stage of retardation on account of the slight waxy appearance of the symphyseal face. This with the relatively incomplete ventral rampart (compared with the clear definition of extremities already formed) and margins indicate retardation in small degree.

We may now proceed to state the features of the sixth phase which runs its course apparently somewhat more quickly in the Negro-hybrid than in the White.

*Sixth phase.* Age 30-33:—Increasing definition of extremities. Formation and practical completion of ventral rampart. Retention of granular or rarefied appearance in symphyseal and ventral aspects of os pubis. Absence of lipping of symphyseal margins.

The seventh phase in the Negro-hybrid starts a little earlier than in the White but likewise continues to a rather uncertain upper limit which, for the sake of definition, we may arbitrarily set as in the case of the White at thirty-nine years. From the evidence presented by the entire Reserve material I feel sure that this date is a very close approximation and the only hesitation which I have in fixing it is due to the fact that about this time certain quasi-pathological appearances may supervene which obscure the typical features somewhat. The specimens falling into this group are (Figs. 20-23), Nos. 638, 705, 709, of age thirty-three; Nos. 74, 475, 594, 606, 664 of age thirty-five; Nos. 225, 416, 538 of age thirty-eight; No. 646 of age forty.

Of these Nos. 538 and 664 possibly show a little retardation but not enough to make them conspicuous. The outstanding feature of all is the rapid disappearance of the granular texture of the ventral aspect and the more gradual disappearance of the granular texture of the symphyseal face, the bone tissue in both places becoming more dense and giving the impression of quiescence. In this stage as in the male White a well marked lipping occurs in the ischium at the site of attachment of the sacro-tuberous ligament but the greater prominence of this ridge of bone in earlier phases in the Negro-hybrid than in the White must not be mistaken for lipping which is quite a



distinct feature to be more fully discussed when the general age changes of the pelvis are considered.

In the later years of this period there appears the first beginning of the formation of a "rim" around the entire symphyseal face giving to it a raised edge even before all sign of activity (i. e. granularity) has disappeared from the surface. This is one respect in which the Negro-hybrid differs from the White. Another is that in the specimens now at hand in the collection the ventral rampart is always complete during this stage. To conclude that completion always occurs in the White would be to imply that secondary erosion may take place even before the fortieth year which is not in accordance with the facts. It may be that we shall eventually meet with Negro-hybrid cases in which the rampart never is completed. In any case the distinction is not of very great significance at present.

The bony outgrowth into the attachment of the gracilis tendon occurring in the same stage of the White is present here also but is not so striking.

By the end of the period the symphyseal extremities are well defined. No lipping of the margin occurs however until the succeeding phase.

The characters of the pubis at this stage are the following:

*Seventh phase.* Age 33-38:—Increasing smoothness of symphyseal face and ventral surface consequent upon diminishing activity. Attempt at formation of a raised edge or "rim" to the entire margin. Completion of the ventral rampart if not already completed in the last phase. Commencing bony outgrowth into attachments of tendons and ligaments, especially the gracilis tendon and the sacro-tuberous ligament.

The three succeeding phases tend to dovetail as in the White and cannot be so clearly separated as the foregoing while the specific features of these phases no longer permit the fine age discrimination for which the earlier phases advanced such important information. Certain minor differences, moreover, are to be observed between the Negro-hybrid and White pelves both in morphological features and in age relationship. Attention must be drawn to these during the discussion.

We therefore take up the consideration of a group of pelves the characteristic feature of which is the smoothness of the symphyseal

and ventral aspects due to inactivity (Figs. 24, 25). These are: Nos. 434, 580, 722 of age forty; Nos. 558, 803 of age forty-one; No. 729 of age forty-five; No. 725 of age forty-seven; No. 441 of age forty-nine; No. 697 of age fifty.

The earlier members of the series are perhaps not very clearly marked off from those of the foregoing group. The criterion used in differentiation is not so much absolute smoothness and inactivity as a certain waxy appearance very difficult to describe but quite appreciable on inspection which characterizes an inactive symphyseal surface. It is important to note that there is no further development of the "rim" around the symphyseal margin beyond that already attained in the previous phase. In two features this series differs from the os pubis of the White male at the same age. In the first place there is commencing lipping of the dorsal margin which is readily palpable and depends not upon the age so much as the condition of the symphysis, being rather more marked in the smoother examples. It is however less marked than in the following phase. The second difference is seen in Nos. 558, 803 and to a less extent in No. 697. This is a small punched out excavation on the ventral aspect adjacent to the ventral margin of the symphyseal face at the junction of upper and middle thirds. It is clearly the forerunner of the ventral erosion which becomes a marked feature of the succeeding group.

As in the White the linear prominence on the ventral aspect for attachment of the gracilis muscle and noted by Cleland as "the limit of attachment of the femoral muscles" (2) is well defined at this stage.

Regarding the last three members of this series there may be some legitimate doubt in the mind of the reader as to whether the age record is really correct. It is necessary therefore to state briefly the reasons which convince me that they are properly included in this study.

No. 725 by the record of his birth was forty-seven years, eight months and two days old at the date of death. The fact that he was a case of mitral regurgitation is worthy of record for we have other cases of mitral disease in which there are indications of accelerated metamorphosis and especially of lipping of various bones which, it might be suggested, have some connection with a rheumatic factor. There is no real evidence for this view in the entire collection and



any possibility of such an impression must be corrected at once. The lipping of the long bones, vertebræ and ribs, the wear of the teeth and the condition of the cranial sutures all conform to the recorded age or a little less.

In No. 441 the inferences to be drawn from the bones mentioned in connection with No. 725 are all in accordance with an age of forty-five or a little more. Since the recorded age is forty-nine the possibility of retardation is not worthy of consideration in this case any more than in the last.

The most striking and at the same time the most significant feature of No. 697 is the commencement of a peculiar cinder-like texture and feel to the vertebræ and ribs. This we have learned to associate with skeletons of fifty years and over. Fifty is the recorded age of the specimen. With this the wear of the teeth accords well. The only feature of the skeleton failing to conform to the stated age is the condition of the cranial sutures which are wildly aberrant in their age relationship indicating certainly not more than twenty-five years. The erratic nature of cranial suture closure has been noted already in the first part of this memoir and it must not be allowed to confuse the very definite age indications of the rest of the skeleton.

For the reasons just enumerated therefore we conclude that skeletons 441, 697 and 725 possess a normal age relationship although we may allow that the symphysis itself may present some indications of retardation which can only be properly adjudged by further experience.

From the age frequency of the series it is apparent that we must give the same approximate limits for phase VIII as were given in the case of the White.

*Eighth phase. Age 39-45:*—Symphysial face generally smooth and inactive. Ventral surface of pubis also smooth and inactive with the exceptions noted above. Extremities clearly defined. No increasing distinctiveness of "rim" of symphysial face beyond that attained in the foregoing phase. Some lipping of dorsal but none of ventral border.

The characteristic feature of phase IX in the male White collection is the appearance and development of a marginal raised edge or "rim" to the symphysial face and during this phase also some lipping of both dorsal and ventral margins takes place. Among our Negro-hybrid males the "rim" formation never proceeds very far and occurs more

erratically as also does the lipping of the dorsal margin. Consequently we cannot clearly differentiate the ninth phase from the eighth on the one hand and from the tenth on the other. Another difference found in the Negro-hybrid is the earlier appearance of secondary erosions. Consequently it is necessary to omit the ninth phase from the category of the Negro-hybrid.

The remaining Negro-hybrid male pelves are referred to the tenth phase the distinguishing feature of which is secondary erosion. The pelves (Figs. 26-32) falling into this group are: Nos. 27, 426, 540, 553, of age forty-five; No. 574 of age forty-six; Nos. 31, 498, 725 of age forty-seven; Nos. 198, 699 of age forty-eight; No. 97 of age fifty; No. 192 of age fifty-one; No. 692 of age fifty-three; No. 433 of age fifty-five; No. 400 of age fifty-six; Nos. 79, 430 of age fifty-seven; No. 327 of age fifty-nine; No. 522 of age sixty-seven; No. 511 of age sixty-nine; No. 399 of age seventy; No. 422 of age seventy-six.

It will be noted that all the pelves in the collection beyond the age of forty-five fall into this group with the exception of three which are referred to phase VIII, namely Nos. 441, 697 and 725. These three are possible examples of retardation of bone metamorphosis. The earliest age at which phase X appears among the male Whites is forty-four as an anomaly. From the age of forty-eight it begins to appear more frequently but not till considerably after fifty does it become anything like general. In the Negro-hybrid collection, on the contrary, it first appears as an anomaly at thirty-nine and becomes almost constant after forty-five. It may be that the relatively small number of Negro-hybrids accounts for this but there are other indications noted here and there throughout this communication which indicate a general speeding up in the later phases of bone metamorphosis in the Negro-hybrid so far as the os pubis is concerned. It will be remembered that upon the basis of the male White alone it was impossible to deny absolutely a pathological factor in the rarefaction and erosion of phase X inasmuch as they frequently occurred in association with irregular ossifications and other plainly pathological features. The Negro-hybrid collection is wonderfully free from such pathological features and I feel therefore confirmed in my impression that both general rarefaction and local erosion are genuine age changes, non-pathological in type, as indeed I have hinted in my former communication.

These Negro-hybrids fall into three categories according to the

manner in which phase X supervenes. In pelves 27, 31, 422, 426, 498, 540, 553 it is the ventral erosion which is the significant feature. In all of these, although there may be some rarefaction of the symphyseal face most pronounced near the ventral margin, there is an erosion at the junction of upper and middle thirds of the ventral margin itself through which the rarefying process clearly proceeded.

In pelves 79, 192, 327, 399, 400, 483, 511, 522, 574, 692, 699 no such ventral erosion occurs but the symphyseal surface is rarefied to a greater or less extent mainly towards the *dorsal* margin. This peculiarity sharply identifies the condition from a late phase VII in which the remaining activity is related more to the ventral margin. In pelves 97, 198, 430 both ventral erosion and surface rarefaction occur in about equal extent and it is not possible to decide which appeared first. Observe that these are not the oldest bones; ventral erosion and surface rarefaction are both variant types of the same phase and neither shows a special age frequency within the phase. Among the male Whites there seems to be a possible preference for the ventral erosion type of commencement in those symphyses the rampart of which has never completely formed. As the ventral rampart is apparently always completely formed in Negro-hybrids there is no evidence to be obtained from them upon this point.

The moniliform lipping characteristic of the ventral margin during this phase in Whites also occurs in the Negro-hybrid and needs no further description. The "rim" formation is not more than rudimentary even in quite senile bones. In No. 97 alone is there any question of possible pathological appearance of the symphyseal face and No. 198 is the only one in which the ventral lipping has proceeded to a bizarre and pathological extent. Dorsal lipping is no different from that found among the male Whites and as in them is scarcely related so much to age as to the phase.

We may therefore summarize the foregoing characteristic features in the following manner:

*Tenth phase.* Age 45 and upward:—Symphyseal face showing rarefaction of a non-pathological nature. Ventral border more or less eroded. Increased lipping of dorsal and ventral margins. No more clear definition of "rim" than in previous phases. Occasional pathological disfigurement.



## INDIVIDUAL DEVIATIONS IN AGE RELATIONSHIP

*Local retardation.*—In the discussion of phase VIII we noted three skeletons, namely 441, 697 and 725, which demonstrated the possibility of retention of the essential features of this phase for five years at least after its usual termination. It was suggested there that further research might definitely establish these skeletons as examples of retardation in bone metamorphosis localized to the os pubis alone.

*Local acceleration.*—We find also three specimens in the male Negro-hybrid collection which upon observation of the pubic bone only, would be estimated as of greater than their real age since the features of the symphysis are undoubtedly those characteristic of phase X. The skeletons are Nos. 515, 682 and 736. It will be well therefore to examine these more fully, taking them in their actual age sequence.

No. 682 (Fig. 33) from a case of mitral stenosis aged thirty-nine, possesses pubic bones the symphyseal faces of which are distinctly eroded at the junction of the upper and middle thirds of the ventral margin. Of this erosion the sharp-edged pits are characteristic. The ventral surfaces of the bones display a waxy deposit of new bone transversely striated by the passage of abnormal blood vessels indicating chronic inflammation. Some lipping of the long bones, the vertebrae and the ribs other than the first pair together with the wear of the teeth and the state of the cranial sutures all bespeak the recorded age. There are no "rheumatoid" features. It is only the os pubis with its pathologically thickened and "bearded" ventral aspect which fails to accord with the stated age. Quite possibly the chronic inflammatory focus has stimulated the early occurrence of breakdown in the ventral symphyseal margin. The tendency to disintegration being a feature of the normal bone it is but natural that erosion should be accelerated by the pathological factor. This specimen and No. 198 already mentioned (p. 14) are however the only examples among the Negro-hybrid males in which a pathological origin for the ventral erosion might be invoked.

We pass on then to the consideration of two specimens displaying uncomplicated age changes. The first of these, No. 515 of age forty (Fig. 34), shows features in its long bones, vertebrae, ribs, cranial sutures and in the wear of its teeth typical of the recorded age. Commencing erosion at the junction of upper and middle thirds of the

ventral symphyseal margin signifies therefore an undoubted acceleration of pubic metamorphosis for which there is at present no adequate explanation.

No. 736 (Fig. 35) like the foregoing is of age forty and again the lipping of long bones, vertebræ and ribs accords with the stated age. The condition of the cranial sutures, the wear of the teeth and the external features of the cadaver point to age forty as a probable maximum. There is however in this skeleton undoubted osteo-arthritis of the knee and elbow joints. In the pubis the ventral symphyseal margin and the ventral third of the symphyseal face show typical erosion.

The conclusion to which one tends from a study of these three specimens is that acceleration has occurred locally in the metamorphosis of the pubic bone from some unknown cause not affecting the remainder of the skeleton. One may also add that pathological factors, which are by no means always or necessarily present, appear to have the power of assisting in this acceleration since it is a process of disintegration. The conclusion here drawn can only be justified however by a more extended survey of our material.

In discussing the great mass of skeletons upon which this memoir is based it is impossible to deal in detail with every specimen. Nor is this necessary for the collection is a permanent one and the observations now recorded can be readily checked over. In the consideration of the male White skeletons therefore I have been most concerned to establish the principles of pubic metamorphosis. At that stage the full presentation of the evidence upon anomalous age relationships could only have served to befog the real purpose of the paper. Now that these principles are clearly before the reader and are confirmed by the collection of male Negro-hybrids we can proceed to a discussion of individual deviations from the typical age relations of the pubic bone change as observed in Negro-hybrids.

In the pages immediately preceding we have noted the occurrence of individuals in the second half of life displaying either a possible retardation on the one hand or a definite acceleration on the other in metamorphosis of the pubic bone unaccompanied by parallel changes in the remainder of the skeleton. To develop the argument in favor of this assertion we must examine the material further in search for other examples of like conditions.

In the male Negro-hybrid material no other cases of retardation restricted to the pubic bone have so far presented themselves but there are three other instances of undoubted localized acceleration. These shall be discussed in order of age.

No. 744 of age twenty-two shows excellently an acceleration of metamorphosis at the pubic symphysis and as a feature of this the typical formation of the ventral rampart. No epiphysial lines remain upon this specimen which is from a man who died of pulmonary tuberculosis and whose skeleton in all other respects is characteristic of age twenty-two. Note that in this example (Fig. 36) the dorsal delimiting margin is beginning to appear and the adjacent parts of the grooves to become filled with a deposit of new bone. The specimen itself, when carefully examined under the newly-formed ventral rampart, shows rarefaction of the ventral part of the symphysial face rather more advanced than one usually finds at this age. The upper part of the surface is covered by a recently united mass of bone, undoubtedly an ossified epiphysial nodule which strongly resembles that in No. 413 (Fig. 9). These features are all characteristic of the latter part of phase two, but in addition there is the appearance of a completely formed and partially fused ventral rampart and lower extremity which have united into one piece with the upper nodule now transformed into an upper extremity. Apparently then the specimen has reached the end of the sixth phase and is, in its bone age, about thirty-three. A second glance however disposes of such an interpretation for the dorsal margin is scarcely more than started and the dorsal platform is visible nowhere. The features with the exception of the anomalous ventral rampart and extremities are all those of age twenty-two. From some cause at present unknown the growth of the ventral rampart has taken place unusually early. No. 744 is one of the rather rare instances in which there is an anomaly in age-relationship of bone change quite local in its occurrence.

There is another suggestion which the condition of No. 744 brings forcibly to mind, namely that possibly formation of the ventral rampart always or usually occurs at a quite early age and that in consequence of its not uniting until much later it is lost in maceration. It will be recalled that Aeby claimed the loss of the finer structural relations of the symphysis in maceration (1). Aeby's statement does not refer however to such features as this. Against the suspicion



also must be quoted the fact that for more than seven years we have been preparing these bones with the utmost care, always on the lookout for epiphyses and separate masses of bone not yet described, that we have discovered such in other parts of the skeleton the discussion of which is not relevant here, but that we have never found at the symphysis any ununited mass of bone save that which becomes the nodule of the upper face rapidly fusing with the face itself. The actual formation of the ventral rampart and extremities, moreover, is of a nature to preclude the loss of portions, since they grow up from the underlying bone and are only partially separated therefrom. The next anomalous specimen to be described in fact, while exhibiting the same end-result, shows a very different manner of ossification.

No. 190 of age twenty-six displays a symphyseal face of which the ventral rampart is almost complete and the extremities well defined (Fig. 37). It belongs to the latter part of phase VI. The clavicular epiphyses are not however completely fused. This fact together with the absence of epiphyseal lines on vertebræ and ribs indicates pretty clearly that the recorded age is correct. The ischia act also as an important check upon the age. It is true that the teeth are somewhat worn and that the sutures of the cranium would indicate more than forty, nevertheless this evidence cannot contradict the very definite indications of the rest of the skeleton.

No. 93 (Fig. 38) is likewise anomalous in the age relationship of the os pubis alone. It is possible that the anomalous shape of the symphyseal outline may be related to this. The stated age is thirty and whereas the teeth and clavicles suggest somewhat less than this the sutures, long bones, vertebræ, ribs and even the ischia indicate rather more. Upon general skeletal considerations we should say that the recorded age is confirmed. The ventral rampart and extremities of the symphysis are however completed and the pubis must be referred to phase VII. This acceleration of pubis alone may be related to its anomalous shape since other instances of similar anomalies in the male White series, especially the short type No. 94 (Fig. 59, Part I), exhibit acceleration.

*General skeletal retardation.*—Attention has already been drawn, during the discussion of the male White pelvis, to the fact that anomalies in age relationship may not be localized to the os pubis alone. Cases in which the entire skeleton is involved may have a possible

causation more definitely suggested but as a rule they are more apt to cause confusion and uncertainty regarding the correctness of the records. Indeed were it not for the elaborate way in which the records are checked and the very precise information which is available in a considerable number of cases in the total collection one would have greater hesitation in presenting the evidence now to be set forth.

The first case to be considered is No. 523 (Fig. 39) the skeleton of an individual, twenty-four years of age, showing some five years' retardation in bony metamorphosis. No gross lesion was observed which might be invoked as influencing the rate of bony change. The condition is then one of unknown origin. In this specimen the iliac epiphyses are almost completely united and the ischial epiphyses are united except for their ramal portions which are still entirely free. No other epiphyses are apparent. The pubic bone presents features characteristic of the first phase but there is a suggestion of the beginning of a dorsal delimiting margin and of the filling up of the hinder extremities of the horizontal grooves by new bone formation. The pubic tubercle is completed and there is not the faintest indication of ventral bevelling. Clearly then the stage of bone formation is the latter part of the first phase and the bone age of the individual is about nineteen years. The other parts of the skeleton justify this conclusion. Turning to the records we find that the age given is twenty-four and the family data are so complete that we know his actual age to be twenty-four years and four days. The case is one of minor delay in bony metamorphosis but there is no evidence in the skeleton either that actual inhibition had occurred or that a prolonged stationary period had been entered upon.

No. 474 is an interesting example of retardation. The stated age of this individual who died from pulmonary tuberculosis is twenty-eight. The clavicular epiphyses are not completely ossified. The epiphyses on the auricular surfaces of the sacrum and those of the sacral attachment of the sacro-tuberous ligaments are incompletely united. All other epiphyses are entirely fused. From these findings one would give the skeletal age as about twenty-five or somewhat less. Reference to the pubis (Fig. 40) would distinctly indicate the third phase which accords with the information given by the rest of the skeleton.

*General skeletal acceleration.*—No. 525 (Fig. 41) of age twenty-two died from pneumonia in City Hospital. We have therefore the

hospital file in addition to the family record to assure us that the age has been correctly stated. No epiphysial lines are discernable except that for the iliac crest which is not of much significance as an age marker. In general the skeleton indicates an age of about twenty-six or rather more but the absence of facets upon the teeth, the result of wear, accords with the stated age and not with that suggested by the skeleton. The pubic bones are unusual in that whereas the left symphysial face is concave in both the vertical and the antero-posterior directions the right face is convex. This anomaly was observed by Aeby (1) and is occasionally met with in the Reserve collection but it appears to be of no functional or real morphological significance. The specimen is of the type which has relatively poorly marked horizontal ridges and furrows and this feature together with the abnormally early appearing ventral rampart tends to mislead one regarding the age indication of the pubis. That the development of the symphysial face is anomalous is clearly indicated by the poor definition of the dorsal margin and the dorsal platform and by the absence of the lower extremity all of which are associated with the more advanced features already described. The ill-defined ventral rampart and upper extremity are being built up on the relatively slightly eroded ventral border. The entire surface presents a waxy appearance which one comes to associate with bone change which has entered upon a period of temporary stagnation. One would say therefore that the pubic bones show an age appearance of between twenty-five and twenty-eight years.

No. 458 (Fig. 42) is another case of generalized acceleration. The skeleton is that of a man of twenty-five dying of endocarditis. Acceleration is shown throughout the skeleton. There are no epiphysial lines on vertebræ, ribs or clavicles and no sign of the junctional lines in the sternal gladiolus, features which indicate an age of somewhat less than thirty. Slight lipping of long bones and the condition of the cranial sutures suggest about thirty-three but the teeth, in their wear, are compatible with about twenty-five. In the pubis the ventral rampart is almost completed but the lower extremity is less defined than one would expect from the condition of the rampart, and the ischia also suggest less than thirty. On the whole one may credit this skeleton with four or five years acceleration.

Regarding No. 330 (Fig. 43) there is some legitimate doubt con-



cerning the age. This is given as twenty-five. My reasons for expressing uncertainty as to whether this specimen should be included in the series of known age are several. The man was killed in an accident and therefore the age is not his own statement. The cranial sutures and the lipping of the long bones indicate approaching thirty-five. The ischia and the pubis also suggest this age. On the other hand the general texture of the skeleton and the wearing of the teeth are quite compatible with thirty years. The specimen is included simply upon the policy of refraining in any way from hand-picking the material. The extremities and ventral rampart are completed and the pubis falls within phase VII. Note also however that the symphyseal face is convex in both directions on the left side and concave upon the right.

No. 326 (Fig. 44) is another case of generalized acceleration. The recorded age is thirty and we at once look to the teeth for confirmation. Unfortunately they are peculiarly worn in consequence of an anomaly of occlusion and therefore do not help in age estimation. The absence of all epiphyses and the lipping of the long bones but not of the vertebrae or ribs indicate between thirty and thirty-five. The cranial sutures suggest about thirty-three. The pubic bones are referable to phase VII which corresponds to the ages thirty-three to thirty-nine and with this the ischia conform. All in all therefore this skeleton exhibits a general acceleration of bone change of about four years.

*Contradictory skeletal age indications of acceleration.*—The next case presents a somewhat different type of deviation. This is No. 448 of age thirty-one confirmed by the case sheet (Fig. 45). There is commencing lipping of the articular margins of the long bones of the legs and to a less extent of the arms. The first costal cartilages are quite considerably ossified and this is interesting for the individual died from phthisis complicated by tubercular abscesses in the sternum, ribs 2 and 3 on the left side and 3 and 11 on the right. Although all epiphyses are united there is no spondylitis and no lipping of the ischia. The wear of the teeth is not greater than one would expect at thirty-one and the cranial sutures indicate little over thirty. The symphyseal face of the pubis is distinctly in phase VII and the ventral aspect is quite quiescent. There is an irregularity in the age indication of the skeleton for pubis, ribs and leg bones suggest about thirty-six, cranial sutures about thirty-three and other features the

stated age of thirty-one. We must therefore examine the collection for further specimens of the same type.

No. 791 (Fig. 46) of age twenty-eight, confirmed by his case sheet at City Hospital where he died from pulmonary tuberculosis, shows a general bone age of between thirty and thirty-five but whereas the cranial sutures confirm this, the wear of the teeth is more compatible with the recorded age. While the symphysis like the ischia also points to about thirty-three it must be admitted that the ventral rampart presents the waxy appearance suggestive of having been formed for some time. This is unusual in relation to the relatively normal, excavated and very granular symphyseal and ventral aspects. On the whole then the acceleration of the skeleton, though definite, displays some points which suggest irregularity.

We thus discover a third grouping of individual deviations, one which may at first cause the reader to feel that too much is being claimed in the matter of estimating age relationships. The justification for this grouping of irregular age relationships within a single skeleton can only appear as the series of publications dealing with age features grows so as to include all the bones. In the building up of the collection all these skeletal features have necessarily been studied and it is impossible to avoid making reference to them and even calling upon them for confirmatory evidence before they are properly presented. It naturally follows that if we accept the two types of deviation which have just been discussed we must also accept the possibility of existence of the group to which we now turn.

*Contradictory skeletal age indications of retardation.*—Skeleton 792 comes from a man of twenty-three who died in City Hospital from pulmonary tuberculosis (Fig. 47). The age given by the family record is confirmed by the hospital file. So far as the rest of the skeleton is concerned there are no unfused epiphyses to be seen on the vertebræ or ribs but those of the clavicles are not yet united. The general skeleton then confirms the stated age. At the knees however there are epiphyseal lines on both femur and tibia, apparently indicating recent fusion. The ramal portions of the ischial epiphyses also are not quite fused. But the symphyseal face is the most striking and indicates an age of approximately nineteen. There is scarcely a suggestion of the dorsal margin and none at all of ventral bevelling. Even the pubic tubercle is not yet completely ossified, yet the subequal hori-

zontal ridges are clearly cut and show no evidence of stagnation of metamorphosis as do those of No. 525 to be described later. We must conclude therefore that there are local retardations of bone-change in the pelvis and possibly also at the knees.

No. 779 (Fig. 48), the skeleton of a man who died from bronchopneumonia at the age of thirty-eight is another instance of irregular though general retardation. This individual died in the Medical Wards of City Hospital so that we have the evidence of his case-sheet to confirm the family record of his age. The cadaver on admission to the Department looked about thirty and we therefore anticipated finding some irregularities. Enough is said in this section of the memoir to show that acceleration or retardation of bone-change may be local or generalized in character. This is precisely parallel with the well recognized fact that external features may uniformly indicate a certain age which may or may not be the real age of the individual. Furthermore there may be more or less local accelerations or retardations in the external age-changes. Age features are not merely superficial; they obviously must appear in every tissue and every cell. Usually the general somatic age relationship extends throughout the body from the surface inwards but not always. The case in point as regards external features looked thirty; the sutures of the cranium suggested much less than this; even the teeth were relatively little worn for thirty-eight. The clavicles show epiphysial lines but there are no unfused epiphyses on vertebræ or ribs. There is an age relationship oscillating between twenty-five and thirty according to the part examined. When we look at the symphysis however we are inclined to state the age as between thirty and thirty-three for the extremities are well formed and the ventral rampart in course of development. The ischia on the other hand more nearly approach in their appearance the actual age of thirty-eight. It is therefore necessary to concede that this individual is irregular in the age relationship of his several parts.

Summing up the facts recorded in this section of the work we note that there are three types of individual deviation from the typical age relationship. The first of these is the type in which the os pubis alone exhibits retardation or acceleration of metamorphosis. In the second the entire skeleton is fairly evenly involved. In the third various



parts of the skeleton differ from each other in the age which they indicate.

In discussing the male Negro-hybrids there has been no effort to draw particular attention to instances of mixed phase as was done in the case of the male Whites. That such instances do occur is apparent from the inclusion of specimens such as No. 744. It is now possible to take the younger specimens, of which group No. 744 is one, and present them as examples of acceleration or retardation as it seemed inexpedient to do in the earlier part of this work. The reason for so doing has already been stated: the basic principles of pubic metamorphosis had not been sufficiently established. Such specimens will in future fall into their appropriate grouping.

In the section dealing with the male Whites it was pointed out that in certain cases phase VIII, IX, or X might supervene upon an earlier phase. It may be remarked that no reference is made to such cases in the present section for the very simple reason that they do not occur.

#### THE RELATIONSHIP OF RACIAL STOCK TO PUBIC METAMORPHOSIS

Having now considered fully the features of the male os pubis in random samples of reasonable size in the White and Negro-White hybrid populations of the United States we are in a position to draw certain conclusions regarding the relationship of human stock to the metamorphosis of this bone which, while perhaps not based upon samples large enough to justify final judgment, are at least admissible pending further study upon more extensive material.

First we observe that the bone change runs through the same phases irrespective of stock, the only difference being that in the Negro-hybrid the features of phase IX do not group themselves so definitely into a localized age period distinct from other features as they do in the White.

Secondly, the age relationships of the successive phases are substantially the same in both populations. It is true however that the remarks just made in regard to phase IX indicate a difference in the later periods. This difference is further emphasized by the following facts.

1. Phase VI terminates somewhat earlier, a year or two possibly, in the Negro-hybrid than in the White. This is off-set however by the lingering of phase VII to the thirty-ninth year as in Whites.

2. The commencement of formation of a "rim" to the symphyseal surface occurs in the Negro-hybrid during the seventh phase, that is to say some ten years earlier than in the White. This rim formation is however quickly aborted and never proceeds to the formation of a well defined raised edge as in the White.

3. Lipping of the dorsal margin occurs some five years earlier in the Negro-hybrid but again this process seems to be arrested before it has gone so far as it is liable to go in the White.

4. The secondary changes characteristic of phase X, namely surface rarefaction and ventral erosion also tend to commence some five years earlier in the Negro-hybrid. This process again seems not to proceed to such disorganization of the pubic bone as occurs in the senile White.

5. A feature possibly associated with but not causally related to the foregoing is the smaller inclination of the Negro-hybrid os pubis to develop a markedly pathological condition.

One may say therefore that while in general the phase-age relationships are in essential agreement the Negro-hybrid shows a marked tendency to pass through the phases occurring in the fourth and fifth decades of life more rapidly than the White by about five years but that in spite of this he does not develop the characteristic features to anything like the same degree as the White. I think this will be clearer if I remind the reader of the similar peculiarity of the Negro-hybrid in external features. We often note that the old American Negro is much better preserved than the White, meaning that he does not develop senile features to the same extent.

Thirdly as regards the various features of the several phases the striking fact is their almost identical nature in the two populations. The only differences are of very secondary importance. Some have been mentioned in the foregoing paragraph; others are the following.

In the first phase the horizontal ridges are subequal in the Negro-hybrid but more massive above in the White. The relation of the ventral rampart and upper epiphysal nodule to the epiphysis of the ischial ramus is better shown in the Negro-hybrid series. The ventral rampart is much more generally completed in the Negro-hybrid so that in the eighth phase the symphyseal margin is always complete.

In addition to the foregoing the collateral feature of the ischium

must not be forgotten. Although actual lipping of the attachment to the ischium of the sacro-tuberous ligament occurs during phase VII in White and Negro-hybrid alike, there is a greater previous development of this ligamentous ridge in the Negro-hybrid population.

Knowing as we do that Negro-hybrids retain many essentially negroid traits and that such traits are readily observable in the pelvis itself we are forced to conclude from this review that, so far as Negro and White pelvises are concerned stock has strikingly little influence upon pubic metamorphosis.

There still remain three aspects of the relationship which eventually must be presented. The discussion of anomalies in the os pubis, especially those related to the symphyseal area, will be taken up after the female pelvises have been considered. The frequency of individual deviations from the typical age relationship of pubic metamorphosis cannot be adequately treated until the amount of material is much greater than it is at present. The influence of racial stock upon the dimensions of the symphysis and even of the os pubis in general will be dealt with in later studies.

### III. AGE CHANGES IN THE PUBIC BONE OF THE WHITE FEMALE HISTORICAL INTRODUCTION

According to Aeby it was Bouvart who first made a comparison of the rate of metamorphosis at the symphysis pubis in the male and female, Haller in 1750 quoting him as authority for the statement that ossification proceeds more slowly and is completed later in the female (see 1). With this statement Aeby found himself unable to agree.

Aeby sought to explain on the contrary that acceleration of ossification in the female is due to the periodic pelvic congestion characteristic of that sex. The physiological condition of the male pelvis, he says, remains the same throughout life whereas the female pelvis undergoes congestion at regular intervals during the prime of life. As a result of this congestion Aeby notes the marked softening of ligaments and holds it not contrary to common sense that vascularity in association with other factors energizes the ossification process. Pregnancy also, according to Aeby, may bring about the same result.

We have already seen that so far as the comparison between the White and Negro-White hybrid males is concerned there is no very



outstanding distinction due to stock in the age relationship of pubic metamorphosis. We now pass to examine in detail the sex factor.

#### TYPICAL METAMORPHOSIS

In the Western Reserve collection are forty-seven female White pelvises of known age between sixteen and seventy-four years. While entirely too small a number for an independent study and also too small to base a final judgment upon as to the influence of the sex factor, we may nevertheless examine these pelvises together with the Negro-hybrid females and upon the combined results form some impression of the relation of sex, taking into account the probability that we shall have at least as much justification for the impression we shall obtain as Aebly had for his quite definite assertions.

As representative of the immediate post-adolescent condition we turn to skeletons 527 and 437 (Figs. 49, 50) of sixteen and eighteen years respectively. In neither case is there any attempt at fusion of the iliac crest epiphysis and whereas there is partial union of the ischial epiphysis with the ischial tuber the ramal portion is still free. On both the epiphysis for the anterior iliac spine is completely united.

On the symphyseal face the horizontal ridges and furrows are similar to those of the male at the same ages except that the pattern is more delicate and there is no distinction in massiveness between the upper and lower ridges. No sign of any margin or of ventral bevelling is present but there is the usual abrupt differentiation and angle between the face and the dorsal and ventral aspects of the bone. There is the abrupt delimitation of the face from the upper aspect of the pubis and the gradual merging of the lower part with the ramus as in the male. One very obvious distinction in these two specimens however is the complete ossification of the pubic tubercle which lies quite a considerable distance from the symphyseal face instead of being very closely associated with it as in the male. As usual at this stage no bony nodules are to be observed fusing with the surface. There being only two skeletons in the first phase we are unable to define precisely the upper age limitation of the phase of which the features may be characterized almost in the terms already used for the male.

*First post-adolescent phase.* Age 16-?:—Symphyseal surface rugged, traversed by horizontal ridges separated by well marked grooves, there being no distinction in size between the upper and the

lower ridges and the whole pattern being more delicate than in the male. No bony (epiphysial) nodules fusing with the surface. No definite delimiting margin. No definition of extremities.

The female White pelves next in order of age are three which form a puzzling group because they present quite diverse features and yet each is of age twenty-five years. They illustrate vividly the extreme difficulty of deducing any conclusions from meager data. Indeed it is only the information which we have culled from the relatively large number of male skeletons which enables us to make use of the female series at all.

\* The first of these pelves, No. 604 (Fig. 51), exhibits the subequal horizontal ridges and furrows with a well-defined dorsal lip, a poor but none the less a real representative of the future dorsal margin. Adjacent to it the furrows are commencing to fill up with finely textured bone. There is a fusing bony nodule at the upper extremity of the symphysial face on both sides. The ventral margin is greatly bevelled owing to rarefaction. The clavicular epiphyses and ramal portions of the ischial epiphyses are almost united but all other epiphyses of the appendicular skeleton and vertebræ are fully fused. A few epiphyses for the heads of ribs alone remain incompletely united. So far then as the general skeleton is concerned it presents the features which we have learned to associate with age twenty-five. This age also is confirmed by the cranial sutures and the wear of the teeth. Nevertheless the pubic bones are clearly at the stage of metamorphosis defined as the later part of phase II and to the condition of the pubic bones the ischia conform. This would correspond in the male with twenty to twenty-one years.

No. 406, also a White female of twenty-five years, has the advantage over the last in possessing a Hospital record to confirm the stated age. Again the epiphyses remaining incompletely fused are those at the sternal ends of the clavicles and the heads of some ribs. In addition the ramal parts of the ischial epiphyses are not quite united. The endocranial sutures and wear of the teeth confirm age twenty-five. The skeleton is therefore in very much the same stage of general metamorphosis as No. 604. The symphysis however presents quite different characters. The differentiation into ridges and furrows is lost through the formation of a dorsal platform near the dorsal margin which is commencing to develop and forming quite a lip. There is considerable

beveling of the ventral portion but no delimitation of extremities. These are undoubtedly features of the third phase and, with the condition of the ischia, suggest that in comparison with this specimen No. 604 is an example of retardation in the pelvis alone.

The third example, No. 269 (Fig. 52) exhibits no unfused epiphyses even on the clavicles but there is no lipping of long bones, vertebrae or ribs. In the present state of our knowledge of the female skeleton we cannot infer more from this than that the skeleton is less than thirty-five years old. The state of the cranial sutures gives no further light. The wear of the teeth distinctly indicates no more than thirty and perhaps less than that. No bony nodules occur upon the symphyseal face which however shows a well formed dorsal margin and platform with some development of both extremities and even partial formation of the ventral rampart. In feature then the os pubis of No. 269 is at least in the late stage of phase V. It may be that further investigation will compel the elimination of this skeleton from those of known age.

Leaving No. 269 for the present we can state from observation of the other two that phases II and III correspond almost exactly in features with those of the male but the age limits of these two phases we are not yet in a position to define. The chief features are the following:

*Second phase. Age ?-25:*—Symphyseal face still rugged. The horizontal grooves are becoming filled near their dorsal limit with new finely textured bone. Bone (epiphyseal) nodules fusing with upper symphyseal face. Dorsal delimiting margin begins to develop. No delimitation of extremities. Ventral bevel commencing.

The very obvious growth of the bone at the site of the dorsal margin and the marked lipping of this margin at this stage indicate there may be greater actual addition of bony substance than in the corresponding stage in the male.

*Third phase. Age 25-26?:*—Symphyseal face shows progressive obliteration of ridge and furrow system. Commencing formation of dorsal platform. Possible presence of bony nodules. Dorsal margin becoming more defined and sharply lipped. Ventral bevel more pronounced. Extremities not delimited.

There is no material at present which illustrates the features of the fourth phase but from examples of the next it is plain that the



procedure already described for the male is characteristic also of the female. The age relationship also must be nearly the same for we have noted that No. 406 of age twenty-five is in the later part of phase III, whereas No. 204 at twenty-seven years exhibits the earliest stage of phase V. Both of these skeletons are reliable as age indicators since their family record is borne out both by the hospital file and by their skeletal features.

From these two we may therefore outline in summary the main missing phase.

*Fourth phase. Age 26-27:*—Great increase of ventral bevelled area. Corresponding diminution of ridge and furrow formation. Complete definition of dorsal margin through the formation of the dorsal platform. Commencing delimitation of lower extremity.

We next turn to two skeletons which exemplify phase V. These are Nos. 204 of age twenty-seven and 514 of age thirty.

In No. 204 (Fig. 53) the ridge and furrow system is entirely obliterated by the dorsal platform and the ventral bevel. The dorsal margin is irregular in outline and sharply lipped. These features are much more characteristic of female pelves than of male and are almost constantly present in varying degree after the age of twenty-five. The lower extremity is fairly developed and the upper is commencing to form on the left side though not as yet on the right. A sporadic effort at formation of the ventral rampart occurs here and there on both sides.

The description just given holds also for No. 514 (Fig. 54) except for the following differences of which the first two are indicative of greater age. The lower extremity is better defined; the upper is more developed; there is no suggestion of a ventral rampart and there are still slight indications of the ridge and furrow system.

From these two we may therefore outline in summary the main characteristic of phase V.

*Fifth phase. Age 27-30:*—Relatively small change in symphysial face and dorsal platform except for sporadic efforts at the formation of a ventral rampart. Dorsal margin increasingly clearly defined and more sharply lipped. Lower extremity better defined. Upper extremity forming with or without the intervention of a bony (epiphysial) nodule.

The sixth phase is represented in our collection by the following

specimens (Figs. 55-58): No. 306 of age thirty-four; Nos. 476, 603, 690 of age thirty-five; No. 552 of age thirty-six; Nos. 118, 421 of age thirty-eight.

The first suggestive fact is the age range of these pelves. It would appear as though the phase were later in its inception and its termination than in either male series previously considered. Against this it must be mentioned that there are no pelves in the series of between thirty and thirty-four years so that pending further accessions there is no direct evidence to justify the raising of the lower age limit. Further, although two specimens of age thirty-eight belong to this phase there are four which properly fall into succeeding ones. Three of age thirty-five belong to phase VI but two belong to phase VII. It is clear therefore that the upper age limit lies somewhere between thirty-five and thirty-eight, that is to say somewhat later than in the male White.

A second feature of the group is the relatively late transformation of the rarefied tissue of the ventral aspect into compact bone. The ventral rampart develops in precisely the same manner as in the male and the symphysial face adjacent to the rampart consolidates correspondingly but the failure of the ventral aspect to follow suit results in the undermining of the rampart in a peculiar way which, in those cases where it occurs, is totally unrepresented in the male and quite characteristic of the female. It is associated, I believe, with retardation of the phase and consequent presence of the last two specimens, Nos. 118 and 421, in this group.

The formation of the ventral rampart occurs in the same manner as in the male. It is built up by the linkage of independent bony nodules in Nos. 421, 522 and 603 but in the others by the gradual growth of a mound of bone which nevertheless is more or less incomplete upon the ventral aspect. Since it is to the region thus remaining rarefied that the fibres of the ventral symphysial ligament are attached it might be surmised that the specimens showing undermining in the clearest degree would also present a deep or otherwise strongly marked pre-auricular notch. This however is not the case: there does not appear to be any relation in degree of development between the two features.

The lipping of the dorsal margin noted in earlier groups of female pelves occurs in this also but without increasing in correspondence with

age. A peculiarity of the dorsal margin in the female is the retention of a pectinate outline, plainly connected with a remnant of the earlier ridge and furrow formation which lingers longer in the female and is still quite evident although faint in Nos. 188, 472, 522 and 603.

The various characteristics of the phase may be summarized in the following manner:

*Sixth phase.* Age 30-36:—Increasing definition of extremities. Development and practical completion of ventral rampart. Retention to a small degree of granular appearance of symphyseal face indicating that activity has not yet quite ceased. Failure of ventral aspect of pubis adjacent to ventral rampart to become transformed into a compact surface. Because of this the rampart is more or less undermined. Retention of pectinate outline of dorsal margin and in slight degree of ridge and furrow system. No lipping of ventral margin and no increased lipping of dorsal margin.

The stage of diminishing activity in the os pubis is shown by the following group of pelves (Figs. 59-61): Nos. 53, 260 of age thirty-five; Nos. 83, 221 of age thirty-eight; Nos. 16, 228 of age forty.

By the beginning of this phase the symphyseal face is already practically quiescent but there is still some undermining and rarefaction of the ventral aspect. The completion of the ventral aspect however rapidly occurs from below upward so that the last site of rarefaction observable is close to the upper extremity. There is indeed very little to differentiate the last stage from an early erosion. No symphyseal rim exists at this stage however, no lipping of the ventral border and no marked bony outgrowth into the tendinous and ligamentous attachments of the pelvis, and thus the observer is guided to the correct phase. It is to be noted that ossification of ligamentous and tendinous attachments apparently occurs somewhat later in the female than in the male.

One striking difference from the condition in the male is the obtrusive way in which the lower extremity juts out from the main mass of the pubis but this does not occur in all specimens. In some no such sexual distinction is discernible.

There is still in some instances a slight remnant of the ridge and furrow system but much less marked than in the last.

From the small number of observations it appears that completion of the ventral rampart always occurs but regarding this feature fur-



ther information is necessary. We may sum up the special characters of the phase thus:

*Seventh phase.* Age 36-40:—Slight changes in symphyseal face and marked changes in ventral aspect consequent upon diminishing activity. No formation of symphyseal rim. No ossification of tendinous and ligamentous attachments. The lower age limit is approximate but the upper is more exactly defined by the material.

General quiescence of the pubic bones is illustrated by the next group of specimens (Figs. 62-65): Nos. 243, 249 of age forty; Nos. 324, 457 of age forty-three; No. 415 of age forty-four; No. 111 of age forty-five.

There is very little comment to make upon this group. All show a symphyseal face and a ventral aspect devoid of erosion or rarefaction. Any lipping of the dorsal margin is entirely that which was already present at the beginning of the phase. There is a slight suggestion of rim formation on Nos. 243 and 457 but upon none of the others. The lipping of tendinous and ligamentous attachments which occurs at an earlier age in the male begins to make its appearance in the female at this stage. In No. 243 the ossification of the gracilis origin is very remarkable but by no means pathological. The symphyseal face of No. 324 is deformed, being concave in the vertical direction on the right side and convex on the left.

In brief then the characteristic features are the following:

*Eighth phase.* Age 40-45:—Symphyseal face and ventral aspect of pubic bone generally smooth and inactive. Oval outline complete. Extremities clearly defined. No distinct "rim" to symphyseal face. No lipping of ventral or increased lipping of dorsal margin. Development of ossification in tendinous and ligamentous attachments especially those of sacro-tuberous ligament and gracilis muscle.

We now pass to the consideration of the later stages of metamorphosis. The following pelves fall into phase IX (Figs. 66, 67): No. 517 of age forty-five; No. 355 of age forty-nine; Nos. 229, 252, 742 of age fifty; No. 411 of age fifty-one.

Upon all these except 517 and 411 the symphyseal rim can clearly be identified. In the case of the former it is still incomplete and in the latter it is obscured by deformity of the bone. There is no suggestion in any of activity, whether primary or secondary in symphyseal face or ventral aspect. No lipping occurs on the ventral mar-

gin and no increased lipping on the dorsal. As in the male series the only doubtful specimen, if one except the deformed No. 411, is rightly appraised as belonging to the border-line age between phases VIII and IX.

The features of the phase may be thus summarized:

*Ninth phase.* Age 45-50:—Symphysial face presents a more or less marked rim. No lipping of ventral and no further lipping of dorsal margin. No secondary erosion or rarefaction.

The last group of female White pelvises comprises the following (Figs. 68, 69): No. 728 of age fifty; Nos. 311, 572 of age fifty-six; Nos. 22, 346, 541 of age sixty; No. 466 of age sixty-two; No. 281 of age sixty-three; No. 234 of age sixty-five; No. 340 of age seventy-two; No. 420 of age seventy-four.

This series differs from the corresponding male group very markedly. In the first place lipping of the ventral margin does not occur except slightly in No. 281. There is likewise no special lipping of the dorsal margin beyond that which apparently is one of the initial features of the margin itself.

Rarefaction starting in the symphysial face also is uncommon: it occurs only in Nos. 22 and 420 and in these it appears to be the result of rarefaction starting from the cancellous tissue within the substance of the bone rather than rarefaction originating in the surface itself. The otherwise invariable mode of commencement is erosion of the ventral margin which however progresses very slowly and is only well marked in Nos. 234 and 340 even in which specimens the erosion does not extend deeply into the symphysial face.

The essential features of the group can be stated very briefly:

*Tenth phase.* Age upwards of fifty:—Ventral margin eroded over a greater or less extent of its length, continuing somewhat into the symphysial face. No increased lipping. Disfigurement only occasional and slight.

#### INDIVIDUAL DEVIATIONS IN AGE RELATIONSHIP

As in the male occasional cases occur where the stage of pubic change fails to conform to the actual age. After discussing the instances presenting themselves in this series we shall be in a position to compare our results with those previously given.

In the consideration of the three specimens of age twenty-five, Nos. 604, 406 and 269, we observed that there was nothing in the records or the skeletal condition of the first and second to cast doubt upon the real age. Nevertheless the os pubis of No. 604 is indicative of phase II whereas that of No. 406 is equally certainly to be allotted to phase III. As the age relationships of the female skeleton are in general the same as those of the male it is apparent that here is evidence of retardation in the female os pubis alone.

For the reasons given in the previous section (p. 29) No. 269 must either be eliminated from the series of pelves of known age or it must be admitted as one showing at least five years acceleration throughout the entire skeleton. Which of these courses should be adopted further investigation upon general age changes is required to decide.

*General skeletal acceleration.*—No. 681 (Fig. 70) has its stated age of twenty-eight confirmed by the City Hospital file. Since all epiphyses are united and no lipping has yet occurred it is difficult in the present state of our knowledge to give the upper age limit more exactly than between thirty and thirty-five. The wear of teeth distinctly indicates twenty-eight or but little more while the fusion of the clavicular epiphyses suggests no less than twenty-six. The cranial sutures indicate thirty to thirty-five. Although the ventral rampart of the symphyseal face is not definitely forming there is the considerable molecular bone growth in this area, one of the methods by which the ventral rampart is formed in the White. The method has been described for White males in part I of this memoir. In addition to the development of the ventral rampart the upper extremity is well formed. We are therefore compelled to refer this specimen to phase VI and to accord it some three years acceleration throughout the skeleton.

Doubt regarding the age of No. 339 (Fig. 71) is raised by the fact of her having committed suicide and her age therefore not being her own statement. But the absence of lipping and spondylitis and the condition of the teeth all confirm the stated age of thirty-eight years. It is true that there is some ossification of the first pair of costal cartilages and that the cranial sutures indicate about forty-five. On the whole one cannot accord this specimen more than three years' acceleration in bone change and with this the pubic bones and ischia very well agree for there is distinct lipping of the latter and



general quiescence of both symphyseal face and ventral aspect of the former.

No. 454 (Fig. 72) is from a woman who died of "malnutrition" at City Hospital and whose case sheet confirms the record of her age as thirty-eight. The malnutrition certainly did not retard the metamorphosis of the skeleton which shows a rather erratic age relationship. The slight lipping of the long bones and the ischia indicates somewhat over forty and this indeed is quite compatible with the condition of the teeth. The cranial sutures suggest much less than thirty-eight and there is no ossification of the first pair of costal cartilages. The os pubis shows a practically quiescent condition of the symphyseal face and the ventral aspect. Upon this record one must admit that although in general the features suggest an acceleration in metamorphosis it is only one of two or three years.

No. 715 (Fig. 73) of stated age forty-seven has no hospital record but the information revealed by the skeleton itself is quite unmistakable. There is marked lipping of all the long bones, ossification of the costal cartilages and spondylitis in the thoracic region. Together these features clearly indicate the close approach of fifty. The estimate is further justified by the commencing cinder-like texture of the vertebræ which in this case are affected before the ribs. The specimen is edentulous but the cranial sutures indicate well over forty. On the whole the stated age is confirmed with the reservation that there may be a slight general acceleration of about two years. The ischia are distinctly lipped and the pubic symphyseal face shows a poorly formed rim but erosion is commencing at the ventral margin so that here also slight acceleration occurs. The case is one therefore of generalized acceleration of metamorphosis in very moderate degree.

The cases showing individual deviation among the White females, as the foregoing record testifies, form a much less interesting group than those of the larger male Negro-hybrid series. This is partly due no doubt to the small amount of material upon which observations regarding the former can be made. Four cases of generalized acceleration occur but in none of them is there any startling deviation. No. 269 alone, included tentatively in the series, shows an acceleration of as much as five years. There is only one case suggestive of localized deviation, namely No. 604, an apparent instance of distinct and quite lengthy retardation. The significance of this apparent re-

tardation is not clear at this stage of the discussion though the similar tardiness in completion of phase VI suggests that it is really no retardation at all but that in the female os pubis there is normally a delay, compared with the male, in the progress of metamorphosis at this stage.

#### THE SEX FACTOR IN THE WHITE STOCK

The description of male and female White series shows that both sexes pass through a single definite succession of phases in the metamorphosis of the pubic bone. There are only a few differences in expression of one or two of the phases and these are of relatively minor consequence. The post-adolescent ridge and furrow system is somewhat more delicate and there is no distinction in massiveness between the upper and lower parts of the symphyseal face as there is in males. A delay of two or three years occurs in the consolidation of the ventral aspect of the pubic bone in the female so that the symphyseal face is already complete and quiescent before the ventral aspect. In the female also an irregular pectinate outline is retained much longer by the dorsal margin which is sharply and very early lipped. These features have special significance in the growth of bone at this site. Ossification of the tendinous and ligamentous attachments on the pelvis begins about five years later in the female. So far as our material goes there are far fewer pathological lesions in the female pelvis; lipping of the symphyseal margins and even erosion of the surface do not occur to the extent found in the male, and when erosion begins it is more orderly in its development. All of these features have but the most meager influence upon the estimate of sex and taken in a single case would be of very doubtful value.

There is however another group of features which is more definitely related to sex and seems to indicate a more vigorous growth associated with delayed metamorphosis in the symphyseal part of the os pubis during the years following close upon puberty. To this subject we shall have to recur in future studies for the incorporation of all the records and observations in this paper would extend it to inordinate length. While therefore we shall omit for the present the consideration and comparison of dimensions in the pubic bone and symphyseal face we may briefly refer to the features which cannot but obtrude themselves in observation of the morphological appearance.

The pubic tubercle is either rapidly being withdrawn from its connection with the symphyseal face soon after puberty as in No. 604, or is already far removed as in Nos. 437 and 527. This is not specially characteristic of the female for it is noticeable in both the preceding male series, but it is true that the specimens with the more distant pubic tubercles are usually female and the site of the tubercle gives the impression of relatively great increase of substance at the symphyseal end of the pubis. Further consideration of this matter must be postponed for the present, but there is evidence that the site of the tubercle is variable in different individuals.

The generally greater distance of the tubercle in females is to be associated with a feature which attracted Cleland's attention, namely the distance from the symphyseal face of the line of attachment of the gracilis muscle (2). As Cleland observes, the distance between these lines on right and left sides is considerably greater in the female than in the male. In his statement Cleland referred to "a middle-aged or old female." This distinction is not invariable according to my observations but when it does occur it is very striking. The obtrusiveness of the ridge is not marked until after the ventral rampart has been formed, that is until phase VII is well advanced or phase VIII begins. No. 243 (Fig. 62) shows the projection exceptionally well at forty years. Although Cleland admitted that the feature could not be used as a sex marker until "ossification is thoroughly completed" and he probably regarded this as some period after the age of twenty-five he was not in a position to carry the observation further. We have seen from the discussion of the male pubis that the marking out of the line in question is causally related to the growth of bone tissue as a rampart upon the ventral bevelled symphyseal area and we must therefore conclude that greater growth takes place at this site in the female than in the male. The difference may be equally well expressed as a relatively higher ventral rampart. Another feature intimately related to the growth of the ventral rampart is the greater outstanding character of the lower symphyseal extremity in the female. This apparently also fell under Cleland's observation and upon it he developed a theory of age-modification in the pelvis as a whole which is beyond the scope of the present discussion.

The prominence of the ventral rampart in the female suggests more vigorous growth or a longer period of growth at the symphysis in the



female and to this the character of the dorsal margin lends color. Instead of developing as in the male by the rather rapid filling of the hinder extremities of the horizontal grooves with new bone, the female dorsal margin becomes lipped at once as a thin edge which takes on a pectinate outline in consequence of the failure of the new bone to fill up the furrows. Indeed it is only during the seventh phase that this pectinate outline is really lost. One could not imagine that actual addition of substance continues at the symphysis up to this period but the peculiarities just mentioned do appear to indicate that there is a somewhat greater growth of bone in the earlier phases of female metamorphosis, although this cannot actually amount to more than one or two millimeters.

Before we leave the question of the sex factor for the present it is necessary to look into the relationship of the various phases to the age of the individual. As I shall shortly show Aeby characterized as inaccurate the assertion of Bouvart, which he quotes, to the effect that ossification proceeds more slowly and is completed later in the female than in the male (1). Observations on the Reserve skeletons however tend to confirm Bouvart's statement and contradict that of Aeby who had much less material than we upon which to base his conclusions and further had not the advantage of examining the entire skeleton and so checking off his observations on age relationship.

So far as our material goes there is evidence of delay in phases III and VI, so that their higher age limits are about two years later than in the male. This means that the commencement of extremity formation and completion of the ventral rampart may be somewhat retarded. But by the end of phase VII the age relationship is again practically the same in both sexes. Upon the basis of Aeby's theory of the relation of periodic pelvic congestion, more especially that of pregnancy, one might question how far this slight retardation of phase VI is influenced by child-bearing. The problem of the connection of pelvic sexual characters in their more marked degree to child-birth has by no means escaped our attention. Before making definite assertions much more work will have to be done. Indeed it is always difficult and in most cases impossible to obtain statements regarding children from or in relation to those females who ultimately find their way into our skeletal series. In the preliminary examination of the body upon arrival in the department all the ear-marks of child-birth are

carefully noted and recorded. Upon the observations so far carried out the evidence is wholly negative. This is in accordance with the conclusion of Hunter (4) that there is no real difference in the region of the symphysis pubis between the pelvis of the parturient and that of the non-pregnant woman. It is also in harmony with Aeby's view that no increase occurs in the actual distance between the pubic bones during pregnancy but that there is a softening and consequent extensibility in the ligaments themselves. No author except Aeby has so far claimed the consequent occurrence of any bone change. I do not believe that pregnancy and child-birth leave any permanent stamp upon the skeleton.

After the seventh phase there is no question of a sexual difference; the age-relationships of the phases do not differ in the female from those in the male. With the exception of the differences afore stated in the third and fourth decades we cannot admit any sexual factor in the age relationship of bone changes in the pubis. Such differences as occur between the ages of twenty and forty years will probably receive further confirmation for they are supported by the collateral evidence of sex differences in the ventral aspect of the os pubis and the lipping of tendinous and ligamentous attachments. Aeby's statement and the elaborate theory which he built up in consequence are directly contradicted by our material.

#### IV. AGE CHANGES IN THE PUBIC BONE OF THE NEGRO-WHITE HYBRID FEMALE INTRODUCTION

The acquisition of female Colored bodies is very difficult in Cleveland so that we possess only twenty-two pelves in the series of known age and even among these one or two may eventually have to be discarded. To use so small a number as an independent unit in this investigation would be of course indefensible. We have already seen however that the sex factor has remarkably little influence upon the age relationships of pubic metamorphosis in Caucasian stock and also that differences due to human Stock are relatively insignificant so far as can be judged from a study of the American Negro-White hybrid male. The chief feature of distinction arising in this investigation is the date of termination of the third and sixth phases. In the male Negro-hybrid the sixth phase is completed two or three years earlier than in the male White whereas in the female White both phases tend

to continue for a year or two longer than in the male. While it is of interest therefore to record the pubic metamorphosis as it occurs in the female Negro-hybrid and note its relation to age, sex and Stock it is naturally the period of the third and fourth decades upon which our interest chiefly concentrates.

#### TYPICAL METAMORPHOSIS

As examples of the first phase we are able to present Nos. 485 and 576 both of age sixteen (Fig. 74). In both the iliac and ischial epiphyses are in process of union with the ossa innominata although there is as yet but little ossification of the ramal portions of the ischial epiphyses. The epiphysial line for the anterior inferior spine is still faintly discernible on No. 576 the dates of birth and death of whom were Aug. 31, 1901, and Jan. 1, 1918, respectively. In accordance with the rather greater age this line is lost upon No. 485. We do not know precisely the date of birth of this individual but the record gives 1900 and the date of death was Jan. 12, 1917.

The features of both specimens are exactly those already given for the female White of like phase and the only special observation necessary is that in No. 576 the pubic tubercle is still an extension of the symphyseal face but in No. 485 it is far removed, independent and completely ossified.

As in the female White series no other specimens occur below the age twenty-five so that the upper age limit of the phase cannot be certainly given. Nevertheless the features may shortly be stated in the following manner:

*First phase.* Age 16-?:—Symphyseal face rugged, traversed by rather delicate subequal horizontal ridges. No bony (epiphysial) nodules fusing with the surface. No definite delimiting margin. No definition of extremities.

Turning next to the two specimens of age twenty-five, namely Nos. 495 and 561 we find difficulties similar to those found in the female Whites of the same age.

No. 561 (Fig. 75) possesses a skeleton which from the recent fusion of clavicular epiphyses, character of cranial sutures and wear of teeth we must conclude is actually of age twenty-five or but little more. The dorsal margin of the symphyseal face is becoming defined and the earliest stage of formation of the dorsal platform is brought about



by the appearance of new bone in the hinder portions of the horizontal grooves. The ventral bevel is fairly considerable but there is no suggestion of extremities or of bony nodules. The specimen is therefore at the border-line between phases II and III and tends to confirm the indication given by the female White pelvis that these phases are a little retarded in their completion compared with the male. We have not sufficient material however to make more than the tentative suggestion.

Indeed the next specimen, No. 495 (Fig. 85) appears to refute the suggestion absolutely, the more so as the information upon it is quite detailed. The date of birth was Jan. 10, 1892 and that of death Jan. 19, 1917. The skeleton as a whole points to about thirty years or rather more by the condition of the clavicles, long bones, vertebræ and cranial sutures although the teeth do not indicate so much. From the external appearance of the cadaver an energetic investigation was immediately taken up to be sure that the correct body had been delivered to us, and as a result of tracing it in its journey from the hospital to the Department there seems no reasonable doubt of its authenticity. It ought therefore to be considered as a case of generalized acceleration and will be so recorded but is brought in at this juncture to emphasize the difficulty of recognizing and establishing age changes except upon a large material. The symphysial face has its extremities recently completed and the ventral rampart newly formed and as yet undermined upon the ventral aspect. The dorsal margin is not so clearly defined as one would expect from the stage to which the other parts have progressed, nevertheless the specimen must be allotted to the border-line between phases VI and VII and would certainly be eliminated from the series of known age but for the precise records.

Upon the basis of the single specimen No. 561 we can state simply that the second and third phases in the female Negro hybrid seem to possess the same features as the male and that the passage of the one into the other may not occur until the age of twenty-five years. If confirmed, this would raise the upper limit of the third phase several years beyond that of the corresponding male and one or two beyond that of the female White. At present no definite age statement can be made but for the sake of completeness the following notes should be recorded regarding phases II, III, IV, the observations being justi-

fied by the evidence of other specimens and by the collateral evidence of other series.

*Second phase.* Age ?-25:—The statement of age relationship is purely provisional. Symphysial face still rugged. Grooves beginning to fill up with new bone at their hinder ends. Commencement of formation of dorsal delimiting margin. No delimitation of extremities. Ventral bevel commencing.

*Third phase.* Age 25-?:—The statement of age relationship is purely provisional. Symphysial face shows progressive obliteration of ridge and furrow system. Commencement of dorsal platform. Dorsal margin becoming more defined. Ventral bevel increasing. No delimitation of extremities.

*Fourth phase.* Age ?-?:—No statement of age relationship is possible at present except the inference drawn from specimens in the collection that the phase begins some time after the age of twenty-five and terminates before twenty-nine. Probably as in the male of very short duration. Increase of ventral bevelled area. Corresponding diminution of ridge and furrow system. Complete definition of dorsal margin through the formation of the dorsal platform. Commencing delimitation of lower extremity.

We now pass on to two skeletons which show almost equally well the very beginning of both extremities. They are No. 704 of age twenty-nine and 589 of age thirty. Both have a clearly defined dorsal margin and a dorsal platform which extends over approximately half the surface towards its ventral limit. The dorsal margin is not specially lipped although it is inclined to show the pectinate outline. The ventral bevel is very pronounced and there are sporadic efforts at the formation of a ventral rampart. The lower extremity is indistinctly formed and the upper is rapidly becoming delimited without the intervention of a bony nodule. The pelves are therefore certainly in the fifth phase which in the male Negro-hybrid is complete at about twenty-nine and in the female White at somewhat over thirty. In the Negro-hybrid female it seems to be the sex factor which is of weight rather than the type of Stock, at least in the third decade.

We have seen that the third phase is delayed in its completion and from the rapidity with which the delimitation of the upper extremity follows that of the lower we may justly infer that the fourth is shortened. This great contraction is not a feature of the male in

either Stock examined, but it is approximated in the female Whites of our collection.

The special characters just outlined may be thus stated:

*Fifth phase.* Age ?-30:—Symphysial face shows well developed dorsal platform and slight and sporadic attempts to form a ventral rampart. Dorsal margin clearly defined and somewhat lipped. Lower extremity still poorly defined. Upper extremity forming without necessarily developing a bony (epiphysial) nodule.

The *sixth phase*, as in the female White series, is well represented in our collection. It comprises the following (Figs. 76-78): No. 461 of age thirty; No. 613 of age thirty-three; No. 529 of age thirty-four; Nos. 128, 520 and 545 of age thirty-five; No. 668 of age thirty-seven.

One notes immediately that whereas the lower age limit is comparable with all the other series the upper age limit disagrees violently with that of the corresponding male group. In the male Negro-hybrid series phase VI is completed between thirty-three and thirty-five. In the female White series on the other hand phase VI does not terminate until between the ages of thirty-five and thirty-eight. Here again in the female Negro-hybrid the sex factor is the important one.

The characters of the phase are those of the same phase in the female Whites and there is again the peculiarity of completion of the symphysial face a considerable time before that of the ventral aspect so that the ventral rampart when almost or quite complete is still considerably undermined by rarefied tissue. No increased lipping of the dorsal margin takes place during this phase and the pectinate outline is especially distinct in some specimens. We may state the characters of this phase simply in summary:

*Sixth phase.* Age 30-37:—Increasing definition of extremities. Development and practical completion of ventral rampart. Retention to a small degree of granular appearance of symphysial face indicating that activity has not quite ceased. Failure of ventral aspect of pubis adjacent to ventral rampart to become transformed into a compact surface. Because of this the rampart is more or less undermined. Retention of pectinate outline by dorsal margin and in slight degree of ridge and furrow system. No lipping of ventral margin and no increased lipping of dorsal margin.

Nos. 315 and 442 both of age forty (Figs. 79, 80) show the beginning of quiescence. The ventral rampart is not thoroughly com-



pleted in either but there is the typical waxy appearance of the surface which denotes the supervention of inactivity. The symphyseal face is already almost smooth and the ventral aspect is rapidly losing its granular surface. The dorsal margin is very little more lipped than in the foregoing phase but there is a suggestion of a rim upon it, an appearance which I had not expected to find in this series. The lipping of the gracilis attachment is well marked in No. 315 but not in No. 442 and in both the ossification of the sacro-tuberous ligament is distinct though much less pronounced than in older specimens.

These two pelves must therefore be assigned to the end of phase VII or the beginning of phase VIII and since we find secondary erosion in bones of forty-five years the age limitations of these two phases may be provisionally outlined as similar to those of the female White.

*Seventh phase.* Age 37-40:—Changes in symphyseal face and ventral aspect consequent upon diminishing activity. Attempt at formation of raised edge or "rim" to margin. Completion of ventral rampart if not already completed during last phase. Possibly commencing ossification of tendinous and ligamentous attachments.

*Eighth phase.* Age 40-45:—Symphyseal face and ventral aspect smooth and inactive. Extremities clearly defined. Possible continuation of attempt at formation of "rim" to symphyseal outline. No marked increase in lipping of dorsal margin. Definite ossification of tendinous and ligamentous attachments.

As with the male Negro-hybrids there are no specimens showing either the characteristic "rim" formation going on to anything like completeness or the lipping of the dorsal and ventral margins found in phase IX. We must admit that so far as the American Negro population is concerned phase IX does not exist as a separate entity.

The remaining pelves must be grouped together as representing phase IX-X. They are (Figs. 81-84): Nos. 530, 685 of age forty-five; No. 516 of age fifty-one; Nos. 152, 331 of age seventy.

All show a well marked lipping of the dorsal margin but very little on the remainder of the symphyseal border, and an aborted "rim" formation. No 152 hardly looks the recorded age but so far no skeletal features have presented themselves by which fine distinctions can be made in such old skeletons. No. 530 shows some erosion of the ventral margin and No. 685 of the symphyseal face although the

latter may well be the beginning of pathological change in this specimen. None of the rest shows any secondary change whatever.

The features in summary are the following:

*Phase IX-X.* Age forty-five and upwards:—Symphysial face shows no well defined "rim" but possibly some rarefaction of surface. Dorsal and to a less extent the ventral margin considerably lipping. Possibly erosion of ventral margin. Pathological disfigurement occasional and slight.

#### INDIVIDUAL DEVIATIONS IN AGE RELATIONSHIP

Among the twenty-two skeletons of this series there are five which demand special notice on account of irregularities in age relationship. They are Nos. 152, 226, 439, 495, 530. Some of these have already been considered.

*General skeletal acceleration.*—No. 495 (Fig. 85), the particulars of which have previously been set forth, shows general acceleration of age changes to such a degree that in spite of the carefully kept and well followed-up record I admit to the series of known age with misgiving and anticipate the possibility of its elimination later when more precision is attained in age estimation.

Another very puzzling case suggesting generalized acceleration is No. 439 (Fig. 86) of age thirty-five years. This was the victim of a street car accident and I have not been able to find out who gave the statement regarding age. Certainly the lipping of the long bones and first costal cartilages suggest forty and the cranial sutures confirm this. The wear of the teeth however is not incompatible with thirty-five or thereabouts and the woman suffered from a peculiar affliction of the bones which resulted in local softening and deformation especially in the pelvis. The specimen therefore remains on the list of those of known age until definite evidence shall be forthcoming that its inclusion is certainly an error. The symphysial face is on the border-line between phase VII and phase VIII and therefore confirms the general skeletal age of about forty.

No. 152 (Fig. 83) of age seventy has also been considered and it was pointed out that in the present state of our general skeletal investigation dogmatic assertions regarding such old skeletons are unwarranted. The texture of the bones in general indicates sixty years and there is advanced arthritis of both wrists and the left shoulder.

The teeth indicate by their wear more than fifty. The pelvic bones lack the shaggy appearance usual in very old specimens but we have not yet sufficient specimens to justify the assertion that such a condition is necessarily present in advanced age. The cranial sutures are compatible with thirty years and no more. There are thus definitely marked anomalies in age relationship in this skeleton whatever the actual age. It is probably best to leave the specimen as unproven but possibly indicating considerable and erratic retardation.

*Local acceleration.*—The two remaining pelves are more easily dealt with since the anomaly is localized to the pubic bone.

No. 530 (Fig. 81) of age forty-five, already provisionally assigned to phase IX-X, shows what appears to be the commencement of erosion upon a ventral border never finally completed. It may be the supervention of phase X on a retained phase VI. Certainly the wear of the teeth, the lipping of the long bones and the vertebræ indicate that the recorded age is correct. The cranial sutures are typical of thirty which is obviously not the real age. The ventral border of the symphysis has a peculiar waxy appearance except in localized areas of erosion and this appearance is characteristic of quiescence. We must classify the pubis therefore as an example of local retardation.

The last anomalous specimen is No. 226 of age thirty (Fig. 87). The teeth are carious and some have been extracted but their wear is clavicles, vertebræ and cranial sutures. There is marked arthritis of both wrists but no lipping of other long bones. So far as the skeleton in general goes there is nothing to call in question the recorded age. The ischia are however distinctly lipped and the pubic bones are in phase VII. The symphyseal height is very short and the symphyseal faces are deformed so that a knife driven through the cartilage of the symphysis would not pass directly backward but would incline toward the left sacro-iliac articulation. From the local acceleration noted in association with short symphyses in previous series one would be inclined to attribute the symphyseal acceleration at least to the same cause which brought about the symphyseal deformity.

#### CHARACTERISTIC FEATURES OF THE FEMALE NEGRO-HYBRID OS PUBIS

Fragmentary as the observations upon so small a series must necessarily be one cannot but note that the Negro-hybrid female resembles the White female in very many of the essential features of pubic meta-



morphosis but that in some the negroid strain is apparent. A full discussion of the sex and stock-linked characters brought out by this investigation follows immediately but it is not out of place to refresh one's memory at this stage with a summary of the facts and inferences just presented.

As in the female White the post-adolescent pattern of the symphysial face is delicate and remains relatively unchanged for a considerable time longer than in the male. In the discussion of the delay in transition from phase II into phase III one recalls the confusion injected into this question by the rival claims of Nos. 604 and 406 among the female Whites. Nevertheless by the end of phase V there is substantial agreement once more in all the series as to time relationship.

Again as in the female White series there is a lagging in completion of the sixth phase and in this respect there is a marked distinction between the male and female hybrids.

Female peculiarities are evident in the completion of the symphysial face long before the ventral aspect of the pubic bone, in the pectinate outline and early sharp lipping of the dorsal margin, in the failure or slight nature of the later lipping of the symphysial border and in the collateral feature of delayed ossification in the attachments of tendons and ligaments.

One very striking difference however from the condition in the female White is the absence of any suggestion of relatively great growth in the symphysial region of the pubic bone. There is no wide separation of the lines of gracilis attachment even in skeletons over forty; there is no relatively prominent ventral rampart and there is no marked outstanding of the lower extremity. The pubic tubercles are indeed widely separated in many cases but in many others they are not even visible. The specific sex character which so powerfully attracted Cleland's attention fails when applied to the Negro-hybrid.

The female Negro-hybrid resembles the male of the same stock in the apparently invariable completion of the symphysial outline, in the early and abortive attempt at the formation of a raised edge or "rim" to the symphysial margin, in the absence of phase IX as a separate entity, in the slight extent of secondary change and in the infrequency of pathological disfigurement.

## ASSEMBLED RESULTS OF THE INVESTIGATION

## FEATURES OF PUBIC METAMORPHOSIS ATTRIBUTABLE TO SEX AND STOCK

Now that the life history of pubic metamorphosis as it relates to both sexes of the White and Negro-White hybrid populations of the United States has been fully described it is possible to draw some conclusions regarding the linkage of various features with sex and with racial Stock. In spite of the disadvantages resulting from lack of a really pure Negro strain with which to make comparison one is emboldened to attack the latter problem because our negroid population retains even in its admixture the characteristic features of the Negro pelvis in general and therefore may reasonably be expected to betray its negroid origin in the detail of the processes by which this final definite result is brought about. In the absence of information concerning the corresponding stages in the full-blooded Negro pelvis one may infer with reason that such differences from the metamorphosis of the White population as are shown by the Negro-hybrids would be still further emphasized in the African Negro.

In the case of the Whites no effort has been made to segregate such different races as the Nordic, Alpine or Mediterranean partly because of the difficulty of obtaining all the necessary information needed to render this possible, partly because many of the individuals whose skeletons are utilized in this survey were native born Americans whose ancestry is even more involved and obscure than that of the immigrants, and partly because the problem at large, in the present stage at least, relates to the influence of Stock rather than of Race.

Concerning the size of the samples of population in the present survey it may be objected that they are too small to serve as a basis for any final or sweeping conclusions. In a statistical review this would undoubtedly be the case and it will be noted that I have contented myself for the moment with recording methods of measurement and the reasons therefor but defer the presentation of averages and indices until such time as the collection is great enough to warrant mathematical consideration. Without a much larger material of hybrids and females a comparison of measurements reduced mathematically would be of little significance. It is otherwise however with the morphological features which are now under discussion. The establishment of the salient facts of metamorphosis rests upon the examination of about five hundred male White pelves of which three hundred are

included in the earlier part of this memoir. The presentation of these facts forms a satisfactory background for the life-history of the Negro-White os pubis represented in this work by more than one hundred pelves of both sexes. Taking White and Negro-hybrid populations together almost eighty female pelves have been utilized. Since these accumulate far more slowly than the male and since quite definite distinctions in metamorphosis are indicated even by this number especially in phases which are well represented in the collection I have not hesitated to set forth the evidence offered by our present material in relation to the influence of sex, recognizing fully the possibility of later modification in minor details with the accumulation of more extensive data.

As to the size of samples the individual specimens of which can be effectively compared morphologically there are imposed by the bulkiness and perishability of the material limitations which do not apply to tables of measurements. For purposes of comparison of morphological data it is almost essential to have the entire sample laid out for observation at one time. Without this precaution most of the age changes would receive inadequate attention or would fail to make the vivid impression gathered when all the specimens are displayed at once. In practice one finds that, in point of time and space, the sample which can be most conveniently correlated as to morphological detail is one hundred pairs of bones. The examination of so large a sample as the three hundred pairs drawn upon for the initial survey is apt to entail considerable risk of damage to specimens owing to the time necessarily consumed in the investigation, while the maze of detail almost obscures the principles. Yet in no other way is it possible to study accurately the data presented. Conclusions once drawn from a sample of reasonable size can be submitted to confirmation or correction by the examination of further samples, the size of which will be determined largely by the physical limitations of possible accommodation.

#### STOCK-LINKED CHARACTERS

It is not necessary at this stage to recapitulate the various features of pubic metamorphosis. A comparison of White and Negro-hybrid populations has already been made in the description of the



male bones but some amplification is rendered necessary by the consideration of the female pelvis.

In both populations the symphyseal face of the os pubis in youth resembles a diaphyso-epiphyseal plane upon which definite epiphyseal nodules may or may not make their appearance, rapidly fusing with the main bone. In both the symphyseal face is ultimately completed or nearly completed by the growth of a margin divisible into dorsal and ventral borders and upper and lower extremities. Furthermore the ventral border and extremities may or may not involve in their composition epiphyseal nodules. In the Negro-hybrid the involvement of a definite bony nodule in development of the lower extremity and of a succession of nodules, which speedily unite to form bony bridges, in the growth of the ventral rampart is much more clearly shown although these features are sufficiently evident even in the White. In addition to the obvious manner in which this detail of construction is shown in the Negro-hybrid and certainly to be associated with it is the apparently invariable completion of the symphyseal outline in contradistinction to the White. In the latter the gap, if there be one in the outline, is always in the upper third of the ventral margin and may involve the upper extremity. These significant facts in the building up of the symphyseal outline will receive adequate attention in a later communication dealing with the general morphology of the mammalian os pubis. At present one must leave the problem with the bare observation that the Negro-hybrid exhibits a method of symphyseal construction apparently more primitive than that of the White.

Two features apparently connected with the modification of symphyseal construction in the White Stock are the frequent ill-marked condition or even absence of the ridge and furrow system and the method of formation of the ventral margin.

From part I of this memoir it will be observed that many specimens of the male White os pubis show poorly-developed horizontal ridges upon the symphyseal face. Indeed in some cases they are almost absent. This variation caused considerable confusion at first and seemed to interpose an insuperable obstacle to the age-grouping of specimens in the third decade of life. The investigation of Negro-hybrid Stock shows however that degree of development of the ridge and furrow system is a relatively minor character. Our Negro-hybrid

material of both sexes exhibits no such ill-defined ridges. It is true that examples are also rare in the female White series but this is so much smaller than the male White collection that I am not inclined to lay stress upon the feature as indicative of sex, especially since it is in its essence a secondary character like others which have just been discussed.

From the consideration of our material also it is apparent that the White Stock shows a much greater tendency to loss of the bony nodules from which the ventral rampart is built up than does the Negro-hybrid. Instead of isolated bony nodules linking up with each other and with the osseous deposits of the upper and lower extremities to form actual if temporary bone bridges, many examples of the White Stock present a ventral margin growing by simple linear mound-like addition of bony substance to the ventral part of the symphyseal face. Collateral evidence points distinctly to the bridge-work as the more typically primitive, if one use this word in a guarded sense, and to the gradual accretion or mound formation which is a slovenly, less vigorous bone metamorphosis, as probably a symbol of degeneracy.

As regards the post-adolescent pattern of the symphyseal face, the subequal nature of the horizontal ridges in the Negro-hybrid as distinguished from the White with its more massive upper ridges is of little significance and fades away in the comparison of the females.

The abortive attempt at formation of a "rim" to the symphyseal outline is much more characteristic of the Negro-hybrid but a well marked rim is not invariable in the White especially in the female. Its occurrence is apparently similar to the development of a slight rim to the glenoid margin about the same period of life and concerning its significance there is no evidence to offer at present. Associated with its absence in the Negro-hybrid is the failure of phase IX to develop in that Stock as a definite unit of age change.

The occurrence of "rim" formation, such as it is, in the Negro-hybrid ten years earlier than in the White must be associated with the earlier termination by about two years of the sixth phase and the earlier supervention by five years of phase X in that Stock. All these indicate the more rapid succession of features progressively attained during adult life. But on the other hand from the fact that the Negro-hybrid shows a relatively small amount of secondary ero-

sion and only infrequently any pronounced pathological change such as we have come to associate with senility it must be maintained that the Negro-hybrid becomes senile much more slowly than the White, so far as the pubic bone can exemplify this belief.

In a review of racial Stock characters one must not fail to mention the fact that although lipping of the attachment of the sacrotuberous ligament makes its appearance at about the same time in both Stocks there is a ridge in the Negro-hybrid, at an earlier age, much more marked in the male sex, apparently typical of the Stock and important only in relation to other instances of the same kind scattered over the skeleton.

There is still another question regarding Stock-linked characters which may receive passing notice at this stage of the investigation, namely the relative frequency of instances of individual deviation from type presented by the White and Negroid Stocks. We have at present no accurate tabulation of data upon which to make such a comparison. Indeed a tabulation would be very difficult to make and probably quite equivocal and unprofitable in the end. We have already seen that there are three types of deviation both of retardation and of acceleration. The selection of material for comparison could not be an easy matter.

Among the White Stock the ancestry of individuals, whether American born or immigrant is quite involved and it is conceivable that there may be differences in precise age relationship between say the more northern Nordic and more southern Mediterranean races. But involved as the problem is for the Whites it is still more difficult in the case of pure Negro Stock of which we have less accurate information regarding the various races. Representatives of various Negro races are undoubtedly present in our collection. We have for example several who show distinctly an ancestry from the tribe which Hawkins exterminated from West Africa when he brought the entire population across the Atlantic as slaves. When therefore the already mixed White and Negroid Stocks formed the hybrid population now known as the American Negro the problem for this hybrid Stock became very complex indeed. All that one can state is that there does not appear to be any marked distinction in number or extent of deviation from type when the White and Negro-White hybrid populations are compared without mathematical reduction.



## SEX-LINKED CHARACTERS

As sex-linked characters in the pubic bone there is evidence in the foregoing descriptions of a modified age relationship in metamorphosis the exact significance of which is not yet clear but it is interesting to note that the female Negro-hybrid resembles the female White much more closely in this respect than she resembles the male of her own Stock. The evidence of this intensifies the probability that there are indeed sex-linked characters.

The various phases of metamorphosis arrange themselves rather naturally into three periods. The first comprises phases I, II, III, and includes early modifications preliminary and in a sense preparatory to the development of the definitive outline of the symphyseal face. During the later part of this period the dorsal margin is indeed forming but not until early in the next is it well defined. The second period includes phases IV, V, VI. This is the period of actual formation of the symphyseal outline although occasionally and for reasons explained in the body of the memoir completion may be deferred till the seventh phase. The third period may be defined as that of relative quiescence which is led up to by phase VII and curtailed by secondary changes in phase X but nevertheless includes phases VII, VIII, IX, X.

In the first two periods there is some normal retardation of metamorphosis seemingly characteristic of the female. This is evinced at precisely those stages where it might be expected to make its appearance. There is delay of perhaps two to three years in the commencement of phase III and some delay, less clearly defined in years by the present available material, in the termination of this phase. The meaning of the phase retardation is of course a retention for a short period longer than in the male of the essentially post-adolescent stage during which actual addition of bony substance is possible.

A more delicate pattern in the ridge and furrow system seems also to be more characteristic of the female sex.

A similar retardation is even more strikingly demonstrated during the second period for although the earlier phases show no real difference in time relation from these in the male the actual termination of the period as indicated by completion of the symphyseal outline occurs on the whole about two years later than in the male and even then changes which are referable in reality to the second period are

still being evinced in the ventral aspect of the pubic bone during the seventh phase. The retardation is even longer and therefore more marked in the female Negro-hybrid than in the female White. In confirmation of the sex-linkage of this delay are various accessory features, namely the early sharp lipping and pectinate outline of the dorsal margin, the peculiarity just mentioned in the completion of the symphyseal face some time before that of the ventral aspect, the later date of appearance of lipping of pelvic tendinous and ligamentous attachments, and in the female White at least the greater distance between the lines of gracilis origin at and after the termination of the period.

During the third period a smaller inclination to lipping of the symphyseal outline appears to be a sex feature.

Before leaving the problem of sex-linked characters it is necessary to note briefly the relation of observations recorded in the present work to those made by Aeby upon the same subject. In all other respects the two investigations are quite harmonious and supplement each other. So far as sex is concerned we have seen that according to my observations there is in the female delay of about two years in the completion of the second and probably also of the first periods of post-adolescent metamorphosis. Aeby measured across the soft tissues of the symphysis upon horizontal sections the distance between the bony symphyseal faces of the ossa pubis at the extreme dorsal and ventral limits. The former he called the dorsal measurement and the latter the ventral measurement. I reproduce below Aeby's table of results in full.

TRANSVERSE MEASUREMENTS THROUGH THE SYMPHYSIS.

Age in Years	MALE			FEMALE		
	No. of Cases	Ventral Measurement	Dorsal Measurement	No. of Cases	Ventral Measurement	Dorsal Measurement
1-14	3	13.7(12-16)	6.7(5- 8)	4	16.2(13-18)	8.3(5-12)
15-30	12	17.3(15-22)	6.4(3-10)	12	19.1(15-23)	7.3(4-13)
30-50	11	10.4( 5-20)	5.4(3-10)	8	9.5( 5-17)	4.6(3- 7)
over 50	13	11.5( 5-21)	4.3(2- 6)	5	11.0 ( 6-19)	4.5(3- 6)

It will be seen that Aeby's investigation was conducted upon 68 specimens of which 39 were male and 29 female. In both dorsal and ventral measurements it is obvious that the female shows a greater

interosseous breadth during the first thirty years but that between thirty and fifty years the interosseous breadth in the female is less than that in the male. Over fifty years there is no sexual differences. From these figures Aeby infers that ossification in the female ossa pubis is more rapid and extensive between thirty and fifty years than in the male and to account for this he develops a theory that the sex difference is due to more energetic ossification in the sexual period of the female brought about by periodic pelvic congestion.

Aeby's remarks concerning this are as follows:

“Woher wohl dieses auffallend wechselnde Verhalten?—So räthselhaft die Sache anfangs auch erscheinen mag, so lässt sie sich doch vielleicht ohne allzugrosse Schwierigkeit erklären. Der physiologische Zustand des männlichen Beckens bleibt sich unter normalen Verhältnissen während des ganzen Lebens ziemlich gleich; nicht so derjenige des weiblichen, das während den Blüthjahren regelmässig in bestimmten Zwischenräumen von mit dem Geschlechtsleben des Weibes zusammenhängenden Blut-congestionen heimgesucht wird. Es ist somit heidurch eine grössere Säftefülle gegeben, und gewiss liegt nichts Widersinniges in der Annahme, dass durch eine solche, so gut wie noch manche andere Prozesse, auch der Verknöcherungsprozess energischer sich gestalte. Eingestretene Schwangerschaft würde ganz in derselben Weise zu wirken vermögen.”

Nevertheless the sentences immediately preceding those just quoted seem to imply that in explaining his results Aeby expressed them incorrectly. Since I am unable to harmonize the latter part of the paragraph quoted below with either the table reproduced above or the earlier part of the paragraph or again with the quotation just made which gives the essence of Aeby's argument I reproduce in full the author's opening remarks.

“Von besonderem Interesse für uns sind die Resultate, welche sich aus einer Vergleichung der Zahlen für beide Geschlechter ergeben. Hier lehrt schon der erste Blick, wie grundlos die so vielfach ausgesprochene Ansicht von grösserer Knorpelbreite der weiblichen Symphyse ist, und wie Unrecht Bouvart hatte, wenn er (a.a.O) bei dieser die Verknöcherung langsamer vorschreiten und erst später vollendet sein liess. Allerdings hat bis zur Pubertät das weibliche Geschlecht einen kleinen Vorsprung vor dem männlichen; allein schon in der folgenden Periode geschieht ein Schritt zur Ausgleichung des Verhältnisses und



nach dem 30. Jahre vermag es ihm kaum mehr gleich zu kommen, geschweige denn es zu übertreffen."

Whatever be the explanation of the discrepancy just alluded to we must not fail to note Aeby's significant statement regarding the age-relationship of pubic metamorphosis as shown in his table. He says that in both sexes while the dorsal measurement diminishes from birth, the ventral at first and up till the age of thirty years takes the contrary course, but afterwards diminishes so much the more rapidly. This is of course exactly in harmony with the description which I have given of the earlier formation of the dorsal margin and the occurrence of ventral bevelling previous to the development of the ventral rampart.

The facts presented in this section of the paper do not enable one to judge of sex or of racial Stock in any individual specimen: they are not the less characteristic of the population as a whole. With sex and Stock determined from other pelvic features they are of assistance in estimating the probable age of the individual specimen.

#### INTERPRETATION OF SECTIONS THROUGH THE OS PUBIS

With the facts of pubic metamorphosis fresh in mind it is particularly instructive to refer in some detail to the observations made more than half a century ago by Aeby (1) since the method used by this author differed radically from the one which I have employed.

Aeby worked upon fresh and unmacerated material mainly with the object of investigating the soft tissues of the symphysis and their relation to the bones. To this end he cut vertical transverse (frontal) and horizontal sections of the symphysis and noted the bony outlines thus brought to view. Aeby's description in summary follows.

Frontal sections through the middle and horizontal sections through the upper third of the symphysis give the desired information concerning the bony outlines. It will be noted that Aeby's horizontal section passes luckily through the exact spot where the ventral margin finally is completed and where secondary erosion is usually first seen. These sections indicate as a general law, according to Aeby, that with the passing of childhood the variety and irregularity of the bony outline increase, later to form once again a single and smooth surface. Further the outline which in the young is formed

of spongy bone very often becomes compact in later age as noted by Henle.

The form shown on frontal section exhibits relatively little change. Whereas the bony border in earlier childhood presents a **low, curved, moderately smoothly rounded outline**, this with increasing age elongates always more towards a **straight line**, merging above by a short sharp curve and below, according to the sex, by a distinct short angle into the pubic bone. The explanation of these features is of course the growth in length of the symphysis up to puberty and the development thereafter of the upper and lower extremities in the manner described in the body of this memoir. In the transformation thus brought about in the bony outline Aeby notes the production of a series of swellings, with more or less interruption, coursing horizontally from behind forwards and "doubtless not without importance for the stability of the union for the cartilage." This is the horizontal ridge and furrow system which I have described and to which, according to Aeby, attention was first directed by Tenon in 1806. Continuing Aeby states that he noted these swellings most developed after puberty when they reach a height of two millimeters or more. But later the formation is not more distinct: it becomes irregular and dwindles more and more, without however completely disappearing, while in great age more or less distinct undulations call it to mind. These observations of Aeby's are in general accordance with those which I have described from the study of macerated bones.

More changing and varied, says Aeby, are the results given by a horizontal section. The bony outline thus disclosed often assumes in children the form of a highly regular semicircle which very soon becomes changed by the tendency to form edges. First the hinder quadrant forms a sharp angle, the ventral on the contrary undergoing a simple extension in consequence of which it forms a blunt angle with the pubis. Thus the circularly cut outline varies and may show two surfaces one directed inwards and one forwards. This summary of Aeby's description indicates the development first of the dorsal margin and the increase of the ventral bevel which is responsible for the production of the two surfaces.

From this point, continues Aeby, there occur various gradations quite constant in relation to age until a stage is reached where the

outlines of the two **symphyseal** surfaces become parallel. Hence Aeby also observed the formation of the **ventral rampart** though he did not recognize it as such. The description of the formation of the **ventral** margin is strikingly confirmatory of the processes which I have discussed. In brief Aeby notes that the free bone margin is rarely regularly symmetrical for upon it varied prominences and incisures occur of which the form is governed not by rule but by chance so that only exceptionally do the two sides correspond. In occasional cases a cartilaginous island is found symmetrically upon both sides surrounded by bone, or a bone island surrounded by cartilage indicating a detached portion of the margin. Nowhere however is there mention of the secondary changes occurring in phase X. Yet Aeby did admit the occurrence of pathological changes although he never observed these going to the extent of actual ankylosis such as Gurlt had described. And in this reservation of Aeby's I must concur for in all our collection of nearly seven hundred pairs of bones no such condition presents itself. There is a suggestion however in the Negro-hybrid male No. 399 (Fig. 29) of age seventy, that pathological ankylosis might have supervened eventually had the patient lived long enough.

As regards age relationships Aeby is less specific, this being due to the fact that he had not access to the age of all the material which he studied, as is clearly shown in legends to his illustrations. Nevertheless he makes several very significant and suggestive observations regarding age relationship, some of which I have noted in the foregoing abstract. It was Aeby's intention to investigate changes in the soft tissue of the symphysis itself brought about by advancing age. For this purpose he measured upon horizontal sections the distance between the hinder extremities of the symphyseal outline and again between the ventral extremities and he noted in contradistinction to its increase in height and antero-posterior diameter with advancing age that the transverse thickness of the intermediary cartilage diminishes in a very peculiar and striking manner. Indeed, as Aeby points out, it confirms what he had written in regard to the pushing forward of the bony margin. While the hinder measurement, he says, diminishes from birth, the ventral measurement up to the age of thirty years takes the contrary course but afterwards certainly diminishes so much the more rapidly. At fifty years, he con-



cludes, the ossification process, if it has not reached its end, has at least sunk to a minimum.

This abstract of Aeby's careful work and accurate observations bears an important relation to the present memoir in two respects. In the first place the two independent investigations figure the same changes resulting in the same final condition of the os pubis. They describe these changes as occurring in the same order and, so far as Aeby's age observations permit a comparison, at the same age periods. Secondly the close agreement of the two descriptions forestalls the objection which might be raised against my work by those insufficiently acquainted with careful technique in bone preparation, namely that the finer structure of the bone might be destroyed or mutilated in the process of maceration. That such an objection is futile is of course shown in the substance of this memoir itself by the fact that although all our skeletons have been prepared by one method and by the same preparators, yet the features exhibited by the bones vary, the variation being in definite sequence and in definite relation to age.

#### THE SIGNIFICANCE OF THE PUBIC TUBERCLE

The pubic tubercle is generally held to lie further removed from the symphysis in the female than in the male and in many cases to ossify from a separate center of lenticular shape and varying dimensions making its appearance more frequently in the female than in the male.

As a result of this investigation I find it is true that the tubercle is characteristically further from the symphysis in the female although this is by no means always the case and the sexual difference is less marked in the Negro-hybrid than in the White. In many individuals of both sexes and populations the tubercle is either insignificant or absent. The most characteristic sex feature is neither the prominence nor the degree of isolation of the tubercle from the symphysis but rather the massiveness of the upper border of the body of the pubis between the symphysis and the tubercle. In the male this is much fuller and more rounded; in the female thinner and with a rather knife-like edge to which the tubercle forms a more or less distinct termination. While in both sexes the tubercle lies approximately at the divergence of the upper and ventral aspects of the

body of the pubis its precise position is liable to a good deal of variation in the vertical direction so that in extreme case it may lie distinctly on the upper aspect or more frequently on the ventral aspect quite removed from the pecten.

As regards ossification I find no instance in which the tubercle possesses a separate epiphysial bony center. Sometimes it is developed from the upper bony nodule upon the symphyseal face, by the extension of which it becomes progressively more removed from the line of symphysis during the first period, that is the first three phases of post-adolescent metamorphosis. But in other and more numerous instances it is already ossified soon after puberty without any indication of a separate center. In these individuals it is already removed beyond the sphere of influence of the upper bony nodule of the symphyseal face. There seems to be no sexual difference in the manner of its formation.

With increasing age, at least up to forty, the tubercle tends to become progressively more prominent in a manner similar to the development of lipping at the tendinous and ligamentous attachments.

#### ANOMALIES OF THE OS PUBIS ESPECIALLY AT THE SYMPHYSEAL REGION

Anomalies of the os pubis fall into two categories according as they relate to shape or to age relationship. The latter class already received sufficient attention in the body of this work but the former has had only scanty and occasional notice. When true variations have been eliminated, namely precise position and relative prominence of the pubic tubercle, individual differences in height and antero-posterior depth of the symphyseal face, and modifications of the symphyseal outline; and when also pathological deformities have been excluded there remain but three features of distinctly anomalous character. These previously attracted Aebly's attention and may therefore be dismissed very shortly. All are rare and since they represent merely forms of variation sufficiently exaggerated to merit notice I do not propose to discuss their frequency. Indeed to do this would require the establishment of a purely arbitrary subdivision between what one should consider normal and what abnormal. Artificial subdivision in a series of small gradations could merely result in confusion and erroneous impressions.

The first anomaly is represented only twice. It is extreme shortness of the vertical symphyseal height and occurs in the White male No. 94 (Fig. 59, Part I) and the Negro-hybrid female No. 226 (Fig. 87). In the former the symphyseal height is on both sides 22 mm., and in the latter 21 mm. Precise directions for the measurement of the symphyseal height have been given in the first part of the memoir and therefore do not need to be repeated. Such reduction of the symphyseal height to little more than half the normal is important not for itself but because with it there goes a marked acceleration of pubic metamorphosis. On reference to the description of these cases given in the appropriate section one notes that No. 94 of age twenty-eight is already in phase VIII and that No. 226 of age thirty is in phase VII. In both examples the acceleration is not general throughout the skeleton but localized to the os pubis alone. In many other cases where the symphyseal height is rather short a certain acceleration of metamorphosis appears to occur but at the present stage the evidence in favor of an intimate and special relationship between the reduction in height and the phase of metamorphosis is naturally less clear in general than in the two specimens just mentioned. In both 94 and 226 moreover the symphyseal outline retains approximately its normal shape. In some others it is relatively very deep anteroposteriorly but such cases are rather infrequent and except for some possible acceleration present no really significant correlated features.

The second anomaly is unequal height of the symphyseal face on the two sides (e. g. No. 524, Fig. 12). Very frequently the heights of the two sides differ by one, two or three millimeters. On two cases among the male Whites was the difference as much as five millimeters. As it is not always an easy matter to measure the real height of the symphyseal face these differences may be to some extent explicable technically. No associated anomalies occur with them and they may be dismissed without further notice. A few specimens not falling into any of the series examined in this work, do exhibit a very pronounced difference in symphyseal height on the two sides. These are cases of old infantile paralysis with very unequal development of the two sides of the pelvis, sufficient to explain the difference in the symphyseal height.

The third anomaly refers to the contour of the symphyseal face. Whereas in the post-adolescent phases it is convex in both directions



with the oncoming of phase VIII it becomes plane or even slightly concave. Very occasionally one surface remains convex and the other becomes concave. Again through anomalous bone metamorphosis the surfaces may be so inclined toward one another so that a knife driven between them through the soft symphyseal tissue would point not directly backwards but to one or other of the sacro-iliac joints. The Negro-hybrid female specimen No. 226 (Fig. 87) is a well marked example.

Apart from these anomalies there is a variation in symphyseal outline which has received no attention in these pages because it appears to have no special significance from any of the points of view from which we have discussed the pubis. As a general rule the outline of the symphyseal face is an elongated oval. Sometimes however the dorsal surface of the body of the bone, and with it the dorsal symphyseal margin, is concave from above downwards. These cases present a reniform symphyseal face (e. g. No. 93, Fig. 38). Either type of outline has its long axis in the vertical diameter.

#### GENERAL SUMMARY OF PARTS II, III, IV

1. There is no necessity in this case to include a classification of pubic bones by phases as was done in Part I. The number being smaller all the specimens utilized are mentioned at the beginning of the description of phases.

2. The general features of pubic metamorphosis described for the male White are confirmed in the female White and in the Negro-White hybrid of both sexes.

3. It is now seen that pubic metamorphosis falls into three periods comprising respectively phases I, II, III; IV, V, VI; VII, VIII, IX, X. The first includes the post-adolescent stages, the second the various processes by which the symphyseal outline is built up and the third the period of gradual quiescence and secondary change.

4. So far as age relationship is concerned the male Negro-hybrids compare almost exactly with the male Whites, the major differences being that in the former the second period terminates with completion of the symphyseal outline about two years earlier and that certain features like lipping and secondary erosion commence some years earlier but do not progress so far.

In age relationship the female Negro-hybrids agree with the female Whites rather than with the male Negro-hybrids. It is characteristic of the female that the first and second periods both terminate about two years later than in the male.

Associated with this retardation are certain features of detail in bone change fully discussed in the conclusions of Parts II and III.

5. As regards the influence of racial Stock upon pubic metamorphosis there are strikingly few differences. Some have been mentioned under 3 above and in these the female participates as well as the male.

6. Following the description of the Negro-hybrid female os pubis in the memoir I have devoted several sections to the consideration of salient features brought out by the research. In them the reader will find a summary of the results of the work.

7. Deviations from the normal in age relationship may occur throughout the skeleton generally, may be localized to one particular bone or region of which the symphyseal face serves as an example, or may be distributed erratically so that different parts of the skeleton exhibit very various deviations in their age relationship.

8. In actual bone growth at the symphyseal region the female White somewhat outsteps the male. This difference is not apparent in the Negro-hybrid and in any case there is very little greater addition of bony substance at this site in the White female than in the male.

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## LEGENDS FOR FIGURES

FIG. 1. Arrangement of ossa innominata in photographic technique.

No. 571. White, male, age 69.

Note position of symphyseal faces of ossa pubis in small square, the right bone being toward the right of figure and left toward left, with ventral margins adjacent. All succeeding figures represent the ossa pubis in this relative position. Figures are reduced to one-half natural size. The variation in dimensions of the bones in the figures is a real indication of the natural variation in size. All are photographed with the symphyseal surfaces in a plane at right angles to the camera axis.

FIG. 2. Polygon of age frequencies in female and Negro-White hybrid material.

In part I dealing with White males the polygon showed relatively numerous individuals of ages ending in 0 or 5, between thirty and fifty years. This feature is not so strikingly shown in the polygon above although the condition is present to a small degree. Reasons for accepting for the present the series of skeletons here presented are given in the text. Some may be eliminated later when the investigation of age changes in the skeleton is completed. The tendency of the female series to group themselves in the columns corresponding to ages ending in 0 or 5 is comparable with the upward leaps of the male White polygon at these same ages. The large number of White females of age thirty-eight may be due to a feminine desire not to reach forty years; it may however be a genuine condition; further investigation of the skeletons will doubtless decide the question.

The number of skeletons in each age group is represented by the ordinates and the ages themselves by the abscissae.

## PLATE I

Os pubis of Negro-White hybrid male. Phases I-IV.

## PHASE I.

FIG. 3. No. 519, age 17. Typical ridge and furrow system, ridges being subequal in size; no indication of dorsal delimiting margin, but sharp differentiation of symphyseal face from dorsal aspect of pubis.

FIG. 4. No. 695, age 18. Features similar to those of Fig. 3; surface slightly damaged so that the thin compact tissue is lost in places revealing the underlying cancellous tissue.

FIG. 5. No. 17, age 19; FIG. 6. No. 588, age 19.—In both of these the features are as in Fig. 3; no ossific nodule apparent on any.



## PHASE II.

FIG. 7. No. 639, age 20.—Dorsal delimiting margin commencing to form; small ossific nodule indicated in upper part of face; early ventral bevel.

FIG. 8. No. 808, age 20.—Dorsal margin slightly better marked; ventral bevel considerably advanced; note that the appearance of cancellous tissue here is the consequence of a physiological process and not an artefact as in Fig. 4.

FIG. 9. No. 413, age 22.—Dorsal margin distinct; dorsal platform indicated; bony nodule large; ventral bevel not pronounced.

## PHASE III.

FIG. 10. No. 366, age 22.—Dorsal margin and platform clearly shown; ventral bevel considerable; disintegration of ridge and furrow system well advanced; bony nodule.

FIG. 11. No. 506, age 23.—Dorsal platform more pronounced; ventral bevel considerable; ridge and furrow system rather persistent; bony nodules not distinct.

## PHASE IV.

FIG. 12. No. 524, age 24.—Dorsal margin and platform very clear; ventral bevel considerable; bony nodules present but ill-defined; first beginning of lower extremity.

## PHASE V.

FIG. 13. No. 802, age 27; FIG. 14. No. 402, age 29.—These show early and later stages in formation of upper extremity with aid of bony nodule following rapidly upon appearance of lower extremity.

## PHASE VI.

FIG. 15. No. 259, age 29.—Earliest beginning of ventral rampart starting from lower extremity.

FIG. 16. No. 486, age 32.—Growth of ventral rampart not very clear; possibly slight retardation; in this and the last there is a distinct remnant of the ridge and furrow system.

FIG. 17. No. 596, age 33.—Ventral rampart nearly completed; extremities well defined.

FIG. 18. No. 677, age 34.—Ventral rampart practically completed; extremities well defined.

FIG. 19. No. 451, age 35.—Features as in last.

## PLATE II.

Os pubis of Negro-White hybrid male. Phases VII-X.

PHASE VII: FIG. 20. No. 709, age 33; FIG. 21. No. 606, age 35; FIG. 22. No. 416, age 38; FIG. 23. No. 646, age 40.—In No. 709 the outline is practically complete; in others it is complete; no rim develops but changes are going on in all symphysial faces.

PHASE VIII: FIG. 24. No. 434, age 40; FIG. 25. No. 729, age 45.—Examples of quiescence of symphysial face: slight lipping of dorsal margin in No. 729 but merely rudimentary rim formation.

PHASE IX-X: FIG. 26. No. 540, age 45; FIG. 27. No. 422, age 76.—Examples of erosion of ventral margin alone; the older specimen shows distinct lipping of the ventral margin.

FIG. 28. No. 574, age 46; FIG. 29. No. 399, age 70.—Examples of erosion commencing in symphyseal face; No. 574 shows in the upper dorsal part of the symphyseal face a pathological osteophytic area which might possibly later have resulted in pathological fusion of the two bones; No. 399 shows well senile lipping of the margins.

FIG. 30. No. 198, age 48; FIG. 31. No. 97, age 50; FIG. 32. No. 430, age 57.—Examples of erosion of both ventral margin and symphyseal face; No. 430 alone probably normal; symphyseal face erosion in No. 97 and osteophytic lipping ventral margin in No. 198 probably pathological.

#### PLATE III

Os pubis of Negro-White hybrid male. Individual deviations in age relationship.

##### *Local Acceleration*

FIG. 33. No. 682, age 39.—Ventral erosion and "bearded" margin are incompatible with other local and general skeletal features and indicate a local acceleration possibly pathological.

FIG. 34. No. 515, age 40.—Commencing erosion at least five years too early.

FIG. 35. No. 736, age 40.—Features similar to those of last.

FIG. 36. No. 744, age 22.—Early and irregular development of ventral rampart; the "epiphyseal" nature of extremities and ventral rampart is very clearly shown here.

FIG. 37. No. 190, age 26.—Local acceleration unaccompanied by anomaly in shape of symphyseal face; ventral rampart already almost complete and extremities well defined.

FIG. 38. No. 93, age 30.—In other cases such an anomalous outline of the symphyseal face is also associated with local acceleration.

##### *General Skeletal Retardation*

FIG. 39. No. 523, age 24.—Features are those of Phase I. FIG. 40. No. 474, age 28.—Features are those of Phase III.

##### *General Skeletal Acceleration*

FIG. 41. No. 525, age 22.—Concavo-convex symphyseal faces; associated with this is anomalous metamorphosis suggesting age 25-28.

FIG. 42. No. 458, age 25.—Ill-definition of lower extremity combined with approaching completion of ventral margin indicates about 30.

FIG. 43. No. 330, age 25.—Doubt is expressed regarding the propriety of including this specimen; concavo-convex type; indicates age 35.

FIG. 44. No. 326, age 30.—Pubic bones indicate Phase VII.

*Contradictory Skeletal Age Indications of Acceleration*

FIG. 45. No. 448, age 31.—Symphyseal face becoming quiescent; ventral aspect of pubis is quite quiescent.

FIG. 46. No. 791, age 28.—Ventral rampart seems to have been formed for some time but has obviously grown up rapidly and left exposed a young-looking symphyseal face.

*Contradictory Skeletal Age Indications of Retardation*

FIG. 47. No. 792, age 23.—Symphyseal face indicates approximately 19 years but lower extremity is already forming through fusion of an "epiphyseal" nodule.

FIG. 48. No. 779, age 38.—Well defined extremities and ventral rampart in course of formation indicate about 32-33.

## PLATE IV

Os pubis of White female.

## PHASE I.

FIG. 49. No. 527, age 16.—Contrast this os pubis with No. 437 in size. They show admirably the great individual variation

FIG. 50. No. 437, age 18.—Surface slightly damaged but nevertheless obviously of Phase I.

## PHASE II.

FIG. 51. No. 604, age 25.—This specimen corresponds with age 20-21 in the male.

## PHASE V.

FIG. 52. No. 269, age 25.—This is an anomalous specimen: see text. FIG. 53. No. 204, age 27.—As in the last there is an early attempt at formation of the ventral rampart. FIG. 54. No. 514, age 30.—Ventral rampart scarcely begun: contrast Nos. 269 and 204.

## PHASE VI.

FIG. 55. No. 476, age 35.—Ventral rampart growing by gradual accretion.

FIG. 56. No. 603, age 35.—Ventral rampart growing by bridge formation; contrast No. 476.

FIG. 57. No. 552, age 36; FIG. 58. No. 421, age 38.—Both show ventral rampart forming by accretion very slowly in manner typical of female.

## PHASE VII.

FIG. 59. No. 53, age 35; FIG. 60. No. 221, age 38; FIG. 61. No. 228, age 40.—

These specimens show very clearly the gradually diminishing activity of the symphyseal face and also the more persistent activity of the ventral aspect especially in its upper portion. Nos. 53 and 228 still show remnants of the ridge and furrow system. It is doubtless such a remnant occurring in some specimens which led Aeby to infer that the system never quite disappears.



## PHASE VIII.

FIG. 62. No. 243, age 40.—Quiescent both on symphyseal face and ventral aspect; remnant of ridge and furrow system; slight suggestion of rim; outstanding lip for attachment of gracilis on ventral aspect near lower extremity especially on left bone.

FIG. 63. No. 249, age 40; FIG. 64, No. 324, age 43; FIG. 65. No. 111, age 45.—All show stage of general quiescence: No. 324 has anomalous symphyseal face, concave right and convex left described in text.

## PHASE IX.

FIG. 66. No. 517, age 45.—The irregular appearance is not true erosion; very slight suggestion only of rim; dorsal lipping more clearly seen on original specimen.

FIG. 67. No. 229, age 50.—Rim clearly seen on original specimen: no marked lipping.

## PHASE X.

FIG. 68. No. 728, age 50.—Slight ventral erosion; very prominent gracilis lip.

FIG. 69. No. 22, age 60.—Early erosion of symphyseal face.

## DEVIATIONS IN AGE RELATIONSHIP

*General Skeletal Acceleration*

FIG. 70. No. 681, age 28.—Shows ventral rampart already forming by accretion.

FIG. 71. No. 339, age 38.—Shows a quiescent symphyseal face very early.

FIG. 72. No. 454, age 38.—Again an early quiescent symphyseal face.

FIG. 73. No. 715, age 47.—Early erosion ventral margin.

## PLATE V

Os pubis of Negro-White hybrid female.

## PHASE I.

FIG. 74. No. 485, age 16.—Shows typical appearance with symphyseal cartilage dried in situ.

## PHASES II, III.

FIG. 75. No. 561, age 25.—This stage corresponds with age 22 in male.

## PHASE VI.

FIG. 76. No. 613, age 33; FIG. 77. No. 529, age 34; FIG. 78. No. 668, age 37.—All show stages in formation of ventral rampart; the condition in No. 613 is somewhat advanced.

## PHASES VII, VIII.

FIG. 79. No. 315, age 40; FIG. 80. No. 442, age 40.—Commencement of quiescence better shown in No. 442; gracilis attachment clearer in No. 315; attempt at rim formation in both.

## PHASE IX-X.

FIG. 81. No. 530, age 45.—Ventral erosion already commencing. FIG. 82. No. 685, age 45.—Erosion starting in symphyseal face. FIG. 83. No. 152, age 70.—Ventral erosion slightly marked; looks younger than 70 years.

FIG. 84. No. 331, age 70.—Typical heavy senile marginal lipping; right bone damaged above.

## DEVIATIONS IN AGE RELATIONSHIP

*General Skeletal Acceleration*

FIG. 85. No. 495, age 25.—Symphyseal outline already completed; indicates border line between Phases VI and VII.

FIG. 86. No. 439, age 35.—Symphyseal face indicates border line between Phases VII and VIII, i. e., about 40 years.

*Local Acceleration*

FIG. 87. No. 226, age 30.—Anomalous concavo-convex symphysis; symphyseal outline completed but ventral aspect not yet quiescent.



FIGURE 1



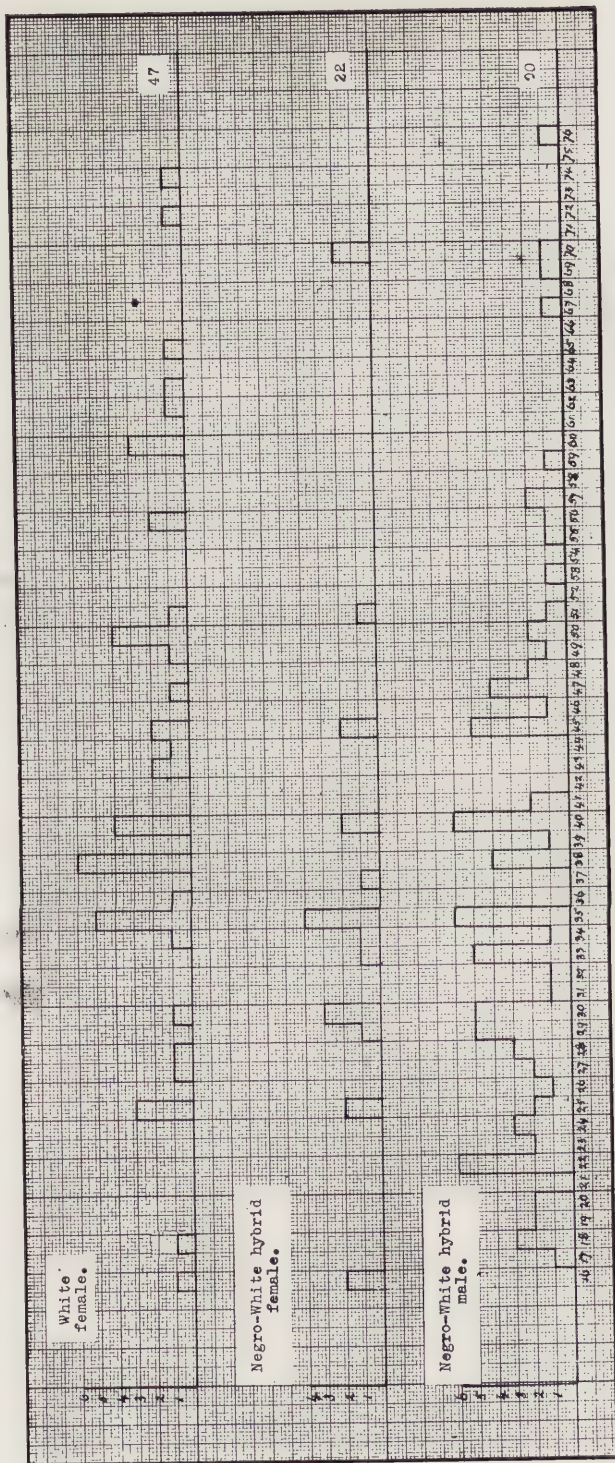


FIGURE II.



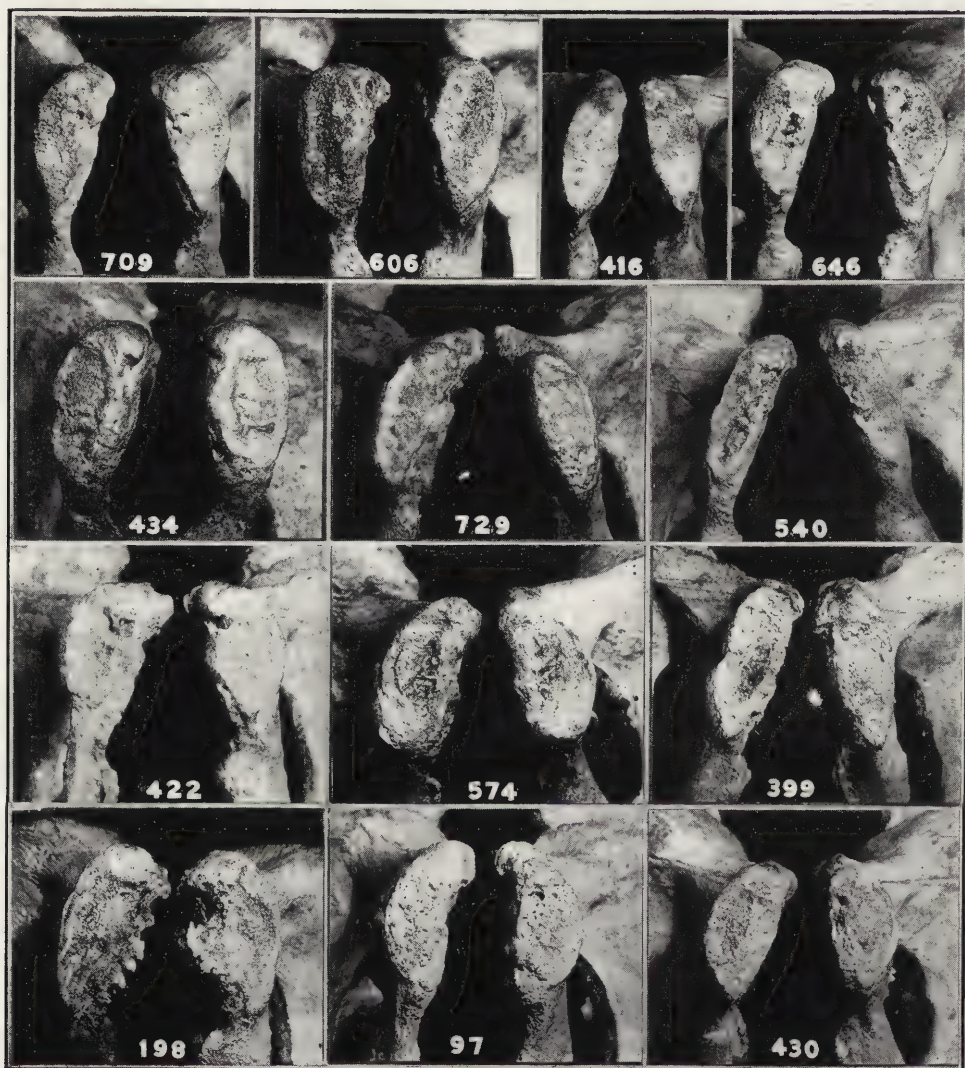
# PLATE I

Uppermost row, Figs. 3, 4, 5, 6.  
 Second row, Figs. 7, 8, 9.  
 Third row, Figs. 10, 11, 12, 13.  
 Fourth row, Figs. 14, 15, 16.  
 Lowest row, Figs. 17, 18, 19.









# PLATE II

Uppermost row, Figs. 20, 21, 22, 23.

Second row, Figs. 24, 25, 26.

Third row, Figs. 27, 28, 29.

Lowest row, Figs. 30, 31, 32.





### PLATE III

Uppermost row, Figs. 33, 34, 35, 36.

Second row, Figs. 37, 38, 39, 40.

Third row, Figs. 41, 42, 43, 44.

Lowest row, Figs. 45, 46, 47, 48.







PLATE IV

Uppermost row, Figs. 49, 50, 51, 52.

Second row, Figs. 53, 54, 55, 56.

Third row, Figs. 57, 58, 59, 60.

Fourth row, Figs. 61, 62, 63, 64.

Fifth row, Figs. 65, 66, 67, 68.

Lowest row, Figs. 69, 70, 71, 72, 73.







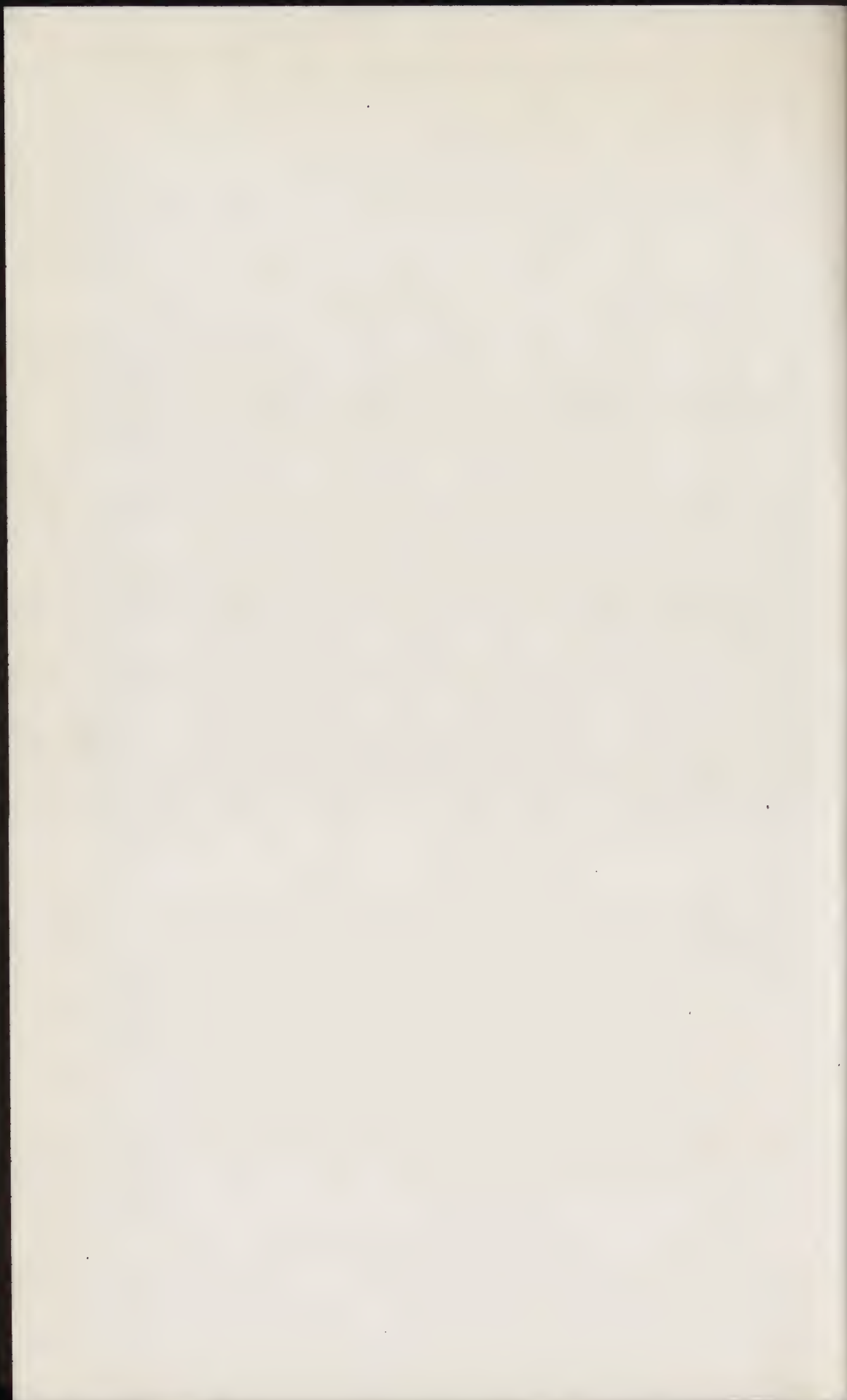
# PLATE V

Uppermost row, Figs. 74, 75, 76, 77

Second row, Figs. 78, 79, 80, 81.

Third row, Figs. 82, 83, 84.

Lowest row, Figs. 85, 86, 87.



## SPECIAL COMMUNICATIONS

### IMMIGRATION

The belated Annual Report of the U. S. Commissioner General of Immigration for the fiscal year ending June 30, 1919, shows that 141,132 aliens entered this country, 30,514 more than in 1918, these figures referring to immigrant aliens solely (i. e. those coming here for permanent residence). . . . During the period covered by this report, 123,522 emigrant and 92,709 nonemigrant aliens left the United States, a total of 216,231. The net increase in population due to immigration was therefore 20,790, as against 18,585 in the fiscal year 1918; 216,498 in 1917; 125,941 in 1916 and 50,070 in 1915. In the 12 months preceding the outbreak of the war in Europe the corresponding increase in our population was 769,276. In addition 218,929 United States citizens left the country, some for travel, some for more or less protracted to permanent residence abroad. For ten years previous to the war the annual average of immigrant aliens admitted was 1,012,194. During the year 8,626 aliens were refused admission, besides which 3,068 were, subsequently to landing, arrested and deported. Of the total 11,694, 318 were defective mentally, 787 physically and 990 morally. The report as usual gives much detailed information, with numerous statistical tables.

### CHILD WELFARE

A striking development in the movement to obtain better conditions for children is described in the pamphlet just issued by the Children's Bureau of the U. S. Department of Labor, entitled "State Commissions for the Study and Revision of Child Welfare Laws."

It is 9 years, according to this pamphlet, since Ohio appointed the first commission to study conditions surrounding children in the State and to codify and revise the laws relating to children. Since that time 16 other States and the District of Columbia have officially recognized the importance of this work by appointing similar commissions, and altogether almost two-thirds of the States have now taken some definite action towards studying legislation as it affects children.



In almost every State where such commissions have been appointed a careful study of conditions in the State and of remedies that have proved successful in other States has preceded suggestions for new legislation or for the revision of existing laws, thus avoiding the danger of hasty and ill-considered action. At the same time a carefully planned educational campaign has been carried on to explain the child-welfare needs of the State and the purpose and scope of the proposed legislation.

The subjects covered include the safeguarding of health, school attendance, regulation of employment, protection against exploitation or corruption of morals, special provision and training of dependent and neglected children, methods of dealing with delinquent children and State supervision of agencies and institutions.

The pamphlet gives a summary of organization and plans of work for each of the States in which commissions have been appointed, and an outline for an index of existing legislation affecting child-welfare. It contains also a list of reports and articles relating to the work of the various commissions and a list of compilations and summaries of laws affecting children.

#### ENGLAND PAYS FOR HEALTHY BABIES

England believes that healthy babies make strong men, and is willing to pay for them, according to reports recently received by the Children's Bureau of the U. S. Department of Labor. In 1918 grants made by the national government in support of infant welfare work in England and Wales amounted to about \$1,150,000, which represents one-half of approved expenditure for welfare centers, "health visitors," maternity care and similar work for mothers and children. The number of health centers increased from 850 in 1917, to 1,550 in June, 1919, over one-half of them supported entirely by public funds. Attendance at the centers has also shown a phenomenal increase. One center in Gloucester, which, in 1918 received 263 expectant mothers, had 932 on its rolls in 1919.

As a result, it is thought, of public protection of maternity and infancy, the infant mortality rate for England and Wales for 1918 is 94. There was no increase over 1917 even under the adverse conditions of war and influenza. The 1918 infant mortality rate for the U. S. birth registration area, just published, is 101, 7 points higher than the rate for the preceding year. U. S. Children's Bureau inves-

tigations have shown that American babies die because they and their mothers do not have skilled care. Until such care is made available, as in England, for all women in all parts of the country, regardless of economic standing, no great decline in the infant mortality rate may be expected.

#### AMERICAN FOUNDATION IN FRANCE FOR PREHISTORIC STUDIES

At the suggestion of Dr. Henri Martin, the well known archeologist of Paris and the discoverer of the ancient La Quina skeleton, and through the efforts of Dr. Charles Peabody, there has been established in this country the "American Foundation in France for Prehistoric Studies, and at the meeting of the Governing Board, held in New York on February 3, 1921, Dr. George Grant MacCurdy was elected the first Director of the Foundation. Dr. Peabody is Chairman of the Board and for the present will also serve as Treasurer.

The object of the Foundation is to provide American students of early man with the opportunities of studying the subject first hand and taking part in further explorations on the rich La Quina site, where further discoveries of value may be expected; it is to constitute a school under whose auspices for a year American students by excavation, travel, examination of various sites, and study in Museums and at lectures in Paris, may get a fair idea of European prehistoric archeology.

The following constitute the Governing Board of the Foundation:

*For the American Anthropological Association:*

Charles Peabody, Chairman;  
George Grant MacCurdy, Secretary, Director of Work;  
Nels C. Nelson.

*For the Archaeological Institute:*

George H. Chase,  
William N. Bates,  
Wallace N. Stearns.

*Members at Large:*

Henry Fairfield Osborn,  
Ales Hrdlicka,  
Edward K. Putnam.

The year's work will open at La Quina (Charente) on July 1st. After a stay of some three months at La Quina, there will be excursions in the Dordogne, the French Pyrénées and to the Grimaldi caves near Mentone. The winter term will be in Paris; and the work of the spring term will include excursions to the important Chellean and Acheulian stations of the Somme valley, to Neolithic sites of the

Marne or other suitable locality, and to Brittany for a study of megalithic monuments. Students may enroll for an entire year or for any part thereof. Those who contemplate entering for either the year or the first term, should communicate immediately with the Director, at Yale University Museum, New Haven, Conn.; or with Dr. C. Peabody, Peabody Museum, Cambridge, Mass. One Foundation scholarship of the value of 2,000 francs is available for the first year. The special qualifications of the applicant, together with references should accompany each application. The Foundation is open to both men and women students. The address of the Director after June 15th will be care of Guaranty Trust Company, Paris.

THE ANATOMICAL AND ANTHROPOLOGICAL ASSOCIATION OF CHINA,  
PEKING

During the Peking Conference of the China Medical Missionary Association and the National Medical Association of China there was organized as already mentioned in the Journal ('20, 281) "The Anatomical and Anthropological Association of China."

One of the foremost objects of the new Association is to establish in the Union Medical College at Peking, the most ample collections of anatomical, anthropological and other scientific material, to serve as study and reference collections available to medical and scientific men who may wish to make use of them. In addition to this everything possible is being done to build up at the Union Medical College an ample reference library in Medicine, Anthropology and allied sciences, where bibliographic service and information may be obtained. Laboratory facilities will also be afforded by the College which will be a centre where medical, anthropological and other scientific investigators will be welcome, and where they may find the greatest possible facilities for their work. No such centre exists as yet anywhere in the Far East, and no place offers at present such opportunities for establishing one as does the capital of the Chinese Republic.

For the beginning the Society meets at least once a month, and the last four meetings were devoted to the following subjects:

Friday, November 26, 1920—The Transplantation of Limbs in Amphibia. S. R. Detweiler, P. U. M. C.

Friday, December 31, 1920—On the Native Tribes of Yunan. V. K. Ting, Geological Survey, Peking.

Friday, January 28, 1921—A Comparative Survey of the Parasites of N. China. E. C. Faust, P. U. M. C.

Friday, February 25, 1921—Physiography of Northern China (With Reference to Man). J. G. Anderson, Peking.



The following circular, prepared with the help of Dr. Hrdlicka, has been printed for distribution to the members and to the different English-speaking medical men and missionaries in China.

### CIRCULAR

#### APPEAL FOR DATA AND MATERIAL OF THE ANATOMICAL AND ANTHROPOLOGICAL INTEREST

##### INFORMATION:

You are earnestly requested to cooperate with and help the Anatomical and Anthropological Association of China by sending in whenever possible information of the following nature:

1. Reliable information, supplemented as far as possible by photographs, is needed; on multiple births, native observances during gestation, childbirth, infancy; binding of feet, deformation (intentional or unintentional) of head, mutilations of any part of the body (practice of emasculation, etc.); on puberty, menstruation, menopause; on marriage customs (from medical standpoint), promptness of conception, contraceptive and abortive practices, native methods of delivery and of meeting its accidents; on reestablishment of menses, length of nursing, commencement of feeding, nature of food, different treatment in any respect of boys and girls; on total number of conceptions (exclusive of miscarriages), and number of latter; on proportion of sexes, at birth and in population (much care should be taken here to avoid hasty generalization); on appearance and nature of signs of senility (in reference to age and class as well as sex, and separating pathological cases).

2. Information (and photographs) is needed bearing on all sorts of monstrosities and congenital defects (cleft palate, hare-lip, ear and other facial defects, syndactylism, polydactylism and other abnormalities of fingers and toes, polymastia, hermaphroditism, pseudohermaphroditism and other genital abnormalities and defects, etc.). In these cases all possible information should be given as to heredity; also the views of natives as to these conditions.

3. Information of a reliable nature is needed on: infanticide; prostitution; abnormal sexual practices; suicides; murders and other forms of criminality.

4. Reliable information is needed on: occurrence and proportion of idiocy, cretinism, acromegaly, simple gigantism or dwarfism (with stature if possible), insanity (and its forms); on local diseases of every kind (with observations on character and prevalence).

5. Carefully made observations are needed on the prevalence and variation in the epicanthus (mongolic fold), on its changes with age; on the variations of the bridge of the nose (low, medium, high), and the root of the nose (nearly flat, low, medium, fairly high—as in Europeans, high. Also: narrow, medium, broad); on the variation of the lips (thin, medium, thick); and on the color of the skin (on body—near white, yellowish, dusky yellow, brownish yellow, and light, medium or dark brown); all observations to be taken in reference to age, for they differ with different periods of life, and with remarks, in connection with the skin, as to its character on the exposed parts of the body.

6. Statistics are needed of actual censuses of small communities and whole villages where possible, as to families, sex and age.

All correspondence with reference to the information solicited in the above list (subjects 1 to 6 inclusive) should be addressed to: Dr. Davidson Black, Department of Anatomy, Peking Union Medical College, Peking.

##### MATERIAL:

You are earnestly requested to cooperate with, and help the Anatomical and Anthropological Association of China by sending in whenever possible, material of the following nature:

7. EMBRYOLOGICAL SPECIMENS:—All embryos and fetuses that can be collected, together with such data as can be obtained (place, date, province, nature of parents, their age and race, cause of abortion, what child in numerical order, etc.) The specimens are best preserved in 10% formalin (4% formaldehyde) but, where this cannot be obtained, alcohol may be used. All charges for preservation and transportation will be defrayed by the College. Special mailing cases for the shipment of material will be furnished on application. All correspondence and specimens should be addressed to: Dr. E. V. Cowdry, Department of Anatomy, Peking Union Medical College, Peking.

8. PHARMACOLOGICAL SPECIMENS, ETC.:—Samples of all herbs and other objects used for medicines and charms together with notes as to their application, prevalence of use, etc. Transportation charges will be defrayed by the College and all specimens and correspondence should be addressed to: Dr. Ralph G. Mills, Department of Pathology, Peking Union Medical College, Peking

9. OSTEOLOGICAL SPECIMENS (HUMAN): All crania and other skeletal remains that can be collected without offense to the natives. The most desirable remains of this nature are those that can be dated, at least approximately (e. g., recent, modern burial, ancient burial, etc.). In all cases as much of the skeleton should be secured as possible, for the pelvis, long bones, spine, etc., are of considerable medical as well as anthropological interest. Fragile or soft bones are benefitted by a free exposure of several days to the air. Pack in sawdust, shavings, dry grass, or any other suitable dry material including crumpled up paper; pack fairly tight, keep remains of different bodies apart; introduce into each skull a slip of paper containing the most necessary information (locality, age, nature of deposits, depth, etc.). To reduce the weight and lessen risk of breakage, earth should be carefully removed from both outside and inside skull. If skull is broken, collect all fragments—it can often be reconstructed. It is most important to save all teeth. There is no limit to the amount of this class of material that is needed. All charges for transportation will be defrayed by the College.

10. PRIMITIVE IMPLEMENTS:—Collect also, alone and with the help of your students and patients, peasants and others, all stones of early historic or pre-historic times that may show evidence of human workmanship—and the same applies to bone implements and fragments of ancient pottery. Specimens should be accompanied by as full data as possible (date of find, detailed description of place and locality of find, etc.). All charges of transportation will be defrayed by the College.

11. VERTEBRATE FOSSILS AND OSTEOLOGICAL SPECIMENS:—Collect all fossil bones and teeth of animals, particularly such as may be found in association with or in the vicinity of human bones. Also skeletal remains of recent mammals especially skulls and teeth. In the case of fossil remains, more particularly fossil skulls, it is advisable to preserve sufficient of the hard surrounding matrix to prevent dissociation of fragments. Specimens should be accompanied by as full data as possible (date of find, detailed description of locality and place of find, etc.). Localities in which fossils are found should be carefully investigated and reported (with detailed information as to location). Send in all fragments (except in the case of huge animals), and especially all teeth. All transportation charges will be defrayed by the College.

12. SPECIMENS OF HUMAN HAIR:—Samples of hair are needed from subjects of both sexes and all ages. The specimens should be obtained from the back or side of the head and should include the middle third of the hair shaft (i. e., should not be restricted merely to the end or underneath part of hair). Specimens should be accompanied by a statement as to the race, sex, age and occupation of the individual from which each was obtained. Each specimen should be carefully wrapped, together with data relating thereto, in separate paper or

envelope. Package of such specimens are best transmitted by letter post. Postage will be defrayed by the College.

All correspondence with reference to the specimens asked for under subject headings Nos. 9, 10, 11, and 12, and all such material, should be addressed to: Dr. Davidson Black, Department of Anatomy, Peking Union Medical College, Peking.

#### THE GALTON SOCIETY FOR THE STUDY OF THE ORIGIN AND EVOLUTION OF MAN

This Society, which was founded on April 2, 1918, has for its object the promotion of study of racial anthropology, and of the origin, migration, physical and mental characters, crossings and evolution of human races, living and extinct.

The charter fellows of the Society are: Prof. E. G. Conklin, Prof. Charles B. Davenport, Mr. Madison Grant, Prof. M. K. Gregory, Prof. George S. Huntington, Prof. J. Howard McGregor, Prof. J. C. Merriam, Prof. Henry Fairfield Osborn, Prof. E. L. Thorndike.

The fellows are: Dr. Ernest Hooton, Dr. Gerrit Smith Miller, Mr. N. C. Nelson, Prof. Raymond Pearl, Prof. Charles R. Stockard, Mr. L. R. Sullivan, Prof. Frederick Tilney, Prof. T. Wingate Todd, Prof. H. H. Wilder, Dr. Clark Wissler, Dr. Frederick Adams Woods, Prof. R. S. Woodworth, Prof. Robert M. Yerkes.

The corresponding members are: Prof. Marcellin Boule, Prof. Arthur Keith, Prof. Georges de Laponge, Prof. Giuseppe Sergi, Prof. G. Elliot Smith.

The patrons are: Mrs. E. H. Harriman, Mr. M. Taylor Pyne.

Chairman, Charles B. Davenport; Secretary and Treasurer, William K. Gregory.

In 1918, 1919 and 1920 the Society has held regular meetings, all but the first at the American Museum of Natural History, at which the following principal topics and demonstrations have been discussed:—

April 17, 1918. *J. H. McGregor*.—Demonstration of a reconstruction of the skull and of a restoration of the head of the Gibraltar woman.

May 14, 1918. *J. H. McGregor*.—Demonstration of a reconstruction of the skull of a typical adult Cro-Magnon man.

*Clark Wissler*.—(introducing Mr. Sullivan's paper) outlined the rise of anthropology in Europe and America and contrasted two concepts of this study, the first as including all lines of investigation on the origin and evolution of human races and of their cultures, the second as limiting anthropology to the study of physical characteristics.

*L. R. Sullivan*.—Races of the Philippine Islands.

*A. L. Kroeber*.—Cultural evidence in the racial history of the Philippines.

Dec. 6, 1918. *J. C. Merriam*.—On the place that anthropology should hold in American universities.

*George S. Huntington*.—On the anatomical basis of racial characteristics—a classification of human variations.

Feb. 19, 1919. *George S. Huntington*.—Classification of human variations (Cont.)  
*Madison Grant*.—Communication from Dr. Charles P. Noble of Radnor, Pa., discussing the physical and mental characteristics of the early settlers in Pennsylvania.



Letter from an officer in the American Expeditionary Force, discussing the relative fighting ability of the different races.

April 15, 1919. *George S. Huntington*.—Classification of human variations (concluded). On the variations in the sacral attachments of the vertebral column in man and anthropoids.

*Madison Grant*.—A communication from M. de Lapouge deploring the effective opposition of the Jews to all studies on the races of France and recording the anthropological investigations by the Germans on their French prisoners of war.

May 21, 1919. *William K. Gregory*.—A Review of the Problem of Man's Relations to the Lower Primates, with special reference to the Evolution of the Human Foot.

*Charles R. Stockard*.—Demonstration of a Pair of Foetal Identical Twins.

Oct. 29, 1919. *Charles B. Davenport*.—Results of the Physical Examination of Two and a Half Million Men.

*J. H. McGregor*.—Demonstration of a reconstruction of an adult Neanderthal man and of corrected restorations of the heads of the Neanderthal and Cro-Magnon men.

Nov. 26, 1919. *H. H. Wilder*.—Palms and Soles: a study of the configuration of the friction skin of Men and Primates.

*Frederick Tilney*.—Comparative Studies on the Structure and Functions of the Brain Stem in Man and the Anthropoids.

*Gerrit S. Miller*.—Could a gorilloid foot give use to the human type? (Observations on the postures of the chimpanzee foot in walking on a flat surface).

Dec. 27, 1919. *L. R. Sullivan*.—Racial identification of certain human remains submitted for examination by the district attorney's office.

*L. R. Sullivan*.—Racial characters of human hair.

*Charles B. Davenport*.—Report on the proposed Eugenics Congress.

*Clark Wissler, Herbert E. Gregory, Alfred C. Mayor, William M. Davis*.—Opportunities for racial studies in the Pacific.

Jan. 28, 1920.—*E. L. Thorndike*.—Psychological tests in the army with reference to racial differences.

*R. S. Woodworth*.—Summary of intelligence tests made on representatives of various races at the Columbian Exposition 1893.

Feb. 25, 1920. *C. R. Stockard*.—Experimental studies on the factors of development and growth; the functions of the ductless glands; bearing on racial differences.

Mar. 18, 1920. (Luncheon in honor of Dr. W. H. Rivers). Informal discussion.

May 4, 1920. (Luncheon in honor of Dr. G. Elliot Smith). Informal discussion.

May 26, 1920. *E. G. Conklin*.—The Limits of Human Evolution.

*H. F. Osborn*.—Opportunities for anthropological study in the Hawaiian Islands (Exhibition of a large collection of photographs of pure and mixed Hawaiians).

Oct. 27, 1920. *C. B. Davenport*.—Anthropometry in the Army.

Nov. 24, 1920. *W. K. Gregory*.—Are the Alpines related to the Mongolians?

Dec. 22, 1920. *Madison Grant*.—European migrations from the north and from the east during the Christian era.

Jan. 26, 1921. *Raymond Pearl*.—The Mathematical Law of Population Growth. *Madison Grant*.—Report on pending immigration bills.

The President and Trustees of the American Museum of Natural History have equipped a laboratory for the study of physical anthropology at the Museum, to be known as the Galton Laboratory, and have invited the Society to coöperate in its direction and in the prosecution of investigations approved by both parties. The Director of the Laboratory is Mr. L. R. Sullivan, who is now in the Hawaiian Islands collecting anthropological data for the Museum and for the Society.

The Society is coöperating with the executive committee of the second International Eugenics Congress in preparing for the Congress, which will be held in New York on Sept. 22-28, 1921.

WILLIAM K. GREGORY  
Secretary.

#### APPEAL

The London "*Eugenics Education Society*" (II, Lincoln's Inn Fields), sends out the following appeal which deserves to be brought to the attention of the readers of this Journal:

The Eugenics Education Society has now for thirteen years fulfilled its function of persistently calling attention to the power which knowledge of Heredity gives to the present generation of influencing the inborn health and ability of future generations. From the outset of our campaign it was evident that many powerful and widespread agencies were at work in the direction of social deterioration, and that these agencies received public approval principally owing to the ignorance of the scientific facts on the part of popular writers and public men. These dysgenic agencies are still at work gradually substituting inferior for superior stock in our population, but the Eugenics Education Society has succeeded so far that the subject is not now entirely disregarded.

At the first we were a voice crying in the wilderness, but it is now generally recognized that Eugenics must be taken into account, and the success of parallel movements abroad has strengthened our position. Nevertheless, if through lack of funds our work is to wane now, which might necessitate a reduction in the number of our educational meetings, and the *Eugenics Review* to be discontinued, there is reason to fear that our efforts will become as much a matter of historical curiosity as Plato's attempt to save from extinction the genius of the Athenæan people.

Financially our position is critical. We appeal to all who have at heart the future of our race to make, if their means permit, a generous

donation for our immediate needs, or voluntarily to double their existing rate of subscription.

*Yours faithfully,*

L. DARWIN,  
*President.*

#### EUGENICS ORGANIZATIONS IN LATIN AMERICA

Progress of eugenics in Latin America is evidenced by the growing attention devoted to this science in the press, and the formation of a number of societies for its promotion.

The medical profession, which occupies a conspicuous position of scientific leadership in most Latin-American countries, has been the leader in the development and organization of public sentiment in this direction.

In Argentina a "Sociedad Eugénica Argentina" has been organized, largely under the inspiration of the distinguished biologist, Dr. Victor Delfino. This society, represented by Prof. Alberto Stuchi, was able at the last South American Congress on Child Welfare to secure the passage of a resolution calling on all governments to endeavor to prevent the marriage of tubercular persons.

Brazil lives up to its record of scientific activity by having two flourishing eugenics societies. In Sao Paulo, which is often called the intellectual capital of the country, is a "Sociedade de Eugénia," of which Dr. Renato Kehl is the general secretary.

In North Brazil the "Sociedade Eugénica do Amazonas" has more recently been established under the initiative of Dr. J. Miranda Leao, director of sanitary service in Manaus. Its headquarters are at No. 9 rua Barroso, Manaus, and Dr. Vicente Gomes de Araujo has been acting as secretary.

Chile has no organization devoted particularly to eugenics, but possesses a strong "Liga Chilena de Higiene Social," of which Senator Eliodoro Yanez is the president. This league is affiliated with the American Social Hygiene Association.

In Mexico the principal advocate of eugenics has been the *Gaceta Médica de México*, which is the organ of the National Academy of Medicine, and is directed by Dr. A. Briosó Vasconcelos, avenida del Brasil 33, Mexico. Dr. Vasconcelos is also one of the secretaries of the Mexican Society for the Prophylaxis of Venereal Diseases.

In Peru the periodical *La Reforma Médica* has likewise been the principal exponent of eugenics, through its editor, Dr. Carlos Enrique Paz Soldán, Apartado 987, Lima, who has done a great deal to edu-



cate public opinion in favor of sound views on racial biology.

Venezuela's Academy of Medicine at Caracas, of which Dr. L. Razetti is permanent secretary and Dr. David Lobo president, has not only made itself the proponent of eugenics, but has taken official action toward the establishment of some sort of organization of eugenics embracing all of Latin America.

At the present time the proposals of the Venezuelan Academy are being carefully studied and discussed by the leaders of thought in all the American countries south of the United States. It is not as yet possible to tell what form final action will take, but apparently public sentiment there is ripe for some sort of comprehensive movement to promote eugenic progress.

THE SOCIAL HYGIENE BULLETIN, 1920, VII, No. 9.

#### A SERIOUS SHORTAGE OF DISSECTING MATERIAL

During the past two years difficulty has been experienced in securing a sufficient number of bodies for dissecting and research in Virginia, and the condition reaches at least to the States of North Carolina, Maryland and Pennsylvania. One of the causes is the unusually low death rate following the war and the epidemic of influenza; another is the increased wealth of the poor; and a third is the activity of certain forms of burial societies.

The teaching of anatomy has been made more difficult because bodies for cross-sections, for prosection and demonstration could not be spared, in some cases the work of one year had to be deferred to the next, and surgeons and undertakers had to be denied bodies for demonstrations. No bodies could be used for anatomical or anthropological investigations, and the students had to be sparing with material.

Fortunately at the University of Virginia the overflow of bodies from the influenza epidemic had been preserved and no acute shortage has yet been felt, but if the condition does not change there will be a shortage next year. From April to August of 1920 only one body was received from the State of Virginia by the Anatomical Board.

The shortage has been greater in small places than in the large cities, and it may be necessary to call upon the big schools to share with the little ones. Voluntary offerings from any quarter will be received with gratitude. All expenses and a nominal honorarium will be paid by the Anatomical Board of Virginia for all bodies received by them.

R. BENNETT BEAN,  
President, Anatomical Board of Virginia.

## LITERATURE

### GENERAL

MANUEL D'ANTHROPOLOGIE PÉDAGOGIQUE. *Basée sur l'anatomo—physiologie de la croissance; méthode auxamologique.* By Godin (Paul)—Paris and Neuchatel (Delachaux), 8°, 1919—43 pp.

This is a supplementary volume to Godin's book on *La Croissance pendant l'âge scolaire*, giving the technique of his method of the study of growth, formerly called by him, *méthode auxamologique*. The *Manuel* cannot therefore be understood without a previous knowledge of the former volume. It gives us the result of twenty-six years of study on growth with an improved method of calculation and interpretation of an exhaustive *individual formula of growth*. In contrast with his previous investigations, where 129 measurements were deemed necessary every six months for a *polymetric* theoretical study, Godin's aim being now practical takes only nine measurements (height sitting and standing, acromial height, height of tip of middle finger, two dimensions of the trunk, and the three main dimensions of the head). These measurements are supplemented by a few psycho-motor tests and a medical statement. These data together with the age in semesters are then worked in graphic and arithmetic form. The formula thus evolved is by far the best result of growth studies. It is however evident that in order to be applied to American children, it should be based on tables of averages different from those of Godin; we have no such tables as yet. Therefore our interest in Godin's method remains speculative and no immediate practical application can be expected here.

JOHN A. MAYNARD.

SOURCE BOOK IN ANTHROPOLOGY. By Kroeber (A. L.) and T. T. Waterman—8°, Berkeley, *Univ. Cal. Press*, 1920, 565 pp.

The volume contains a series of selected articles by various authors, and covering many branches of anthropology. According to the Editors, "The passages in this volume have been selected for their utility in stimulating discussion. They are included not because they present ultimate scientific truth, but because they embody facts and interpretations which are useful for the exercise of thought on some of the larger problems of anthropology. The volume was undertaken and was published in several smaller editions as an auxiliary to an ordinary working library in anthropology. In that stage it embodied chiefly articles which are out of print or accessible in journals of which a library, even a great library, often possesses only a single file. In its present form the volume is intended as the basis for study in courses

of instruction in general anthropology. Any library will provide collateral and special reading."

There are in all 54 articles, ranging from extracts from the Bible (Creation according to the ancient Hebrews) and Herodotus (Greek explanations of geographical and anthropological facts), to old as well as recent contributions to the subjects of physical anthropology, ethnology, religion, man's origin and antiquity, heredity etc. The book while somewhat odd to the professional, is doubtless of considerable help to the student as well as the instructor.

THE PRACTICAL VALUE OF ANTHROPOLOGY TO OUR NATION. By Jenks (Albert Ernest).—*Science*, Feb. 18, 1921, LIII, No. 1364, 149-156.

This paper urges anthropologists to recognize that sciences today develop in very direct ratio to the practical service they render. Argument for practical service is made based on the analogy as seen in the splendid support given to scientific work in agriculture and zooculture. The author urges again the establishment of an anthropological laboratory for the study of modern American anthropological problems, calling attention to a more detailed presentation of the subject published by the Carnegie Institution of Washington in 1914. He illustrates the truth of his thesis by showing how the development of some practical aspects of anthropology under the title of "Americanization Training" at the University of Minnesota is assisting the spread of anthropological studies in American institutions of higher education. The selection and distribution of immigrants, and a four-fold study of the American Negro are subjects outlined as anthropological problems urgently needing scientific investigation that a wise program of national action may be prepared.

A. E. J.

MENSCHENKUNDE. By Buschan (Georg)—8°, new ed., Stuttgart, 1920, 310 pp.

In the words of the author, the book contains a selection of chapters from the natural history of man. It is semipopular in character. It gives considerable information on the subjects of Evolution and Heredity, the Sexes, the bodily and skeletal parts, the internal organs, and anthropometric methods; but notwithstanding the recent date of the edition the text is somewhat antiquated. Also there is a lack of bibliographic references, and the illustrations are not always chosen fortunately—there are some rather repelling nudes. Nevertheless the book seems to have found considerable favor in Germany, for it is stated that the present output brings the total of copies printed to 91,000.

DAS WEIB IN ANTHROPOLOGISCHER UND SOZIALER BETRACHTUNG. By Schultze (O.)—Leipzig, 1920, 64 pp.

A somewhat popular enumeration of the physical secondary sex-



ual characters in white women, comprising sexual differences in body proportions as well as in the skeleton and in the various organs. The consideration of age differences supplements those of sex and leads to the conclusion that woman advances less than man from the infantile state.

A. H. SCHULTZ.

THE HISTORICAL CHILD. By Chrisman (Oscar)—8°, Boston, 1920, 471 pp. (R. J. Badger, \$4).

The author, a Professor of Paidology (the Science of the Child) and Psychology at the Ohio University, has given us a volume somewhat like Plossé's "Das Weib," but somewhat less comprehensive and without illustrations. Also he tells us but little that would be of direct interest to Physical Anthropology of the child; but he promises additional volumes on the subject in which these deficiencies may possibly be compensated for. Outside of this, his book is an earnestly written treatise full of interesting well rounded information on the child, motherhood and womanhood, in older as well as more recent times. He deals with old Mexico, old Peru, old Egypt; with India, China, Japan, Persia; with old Judea, ancient Greece and Rome; with Earlier and Medieval Europe, and with Earlier United States. The field covered will best be indicated by citing some of the sub-headings. The following are those under Egypt: The Country; the People; Slavery; the Home; Women and Marriage; Child and Parent; Dress; Food, Drink; Clothing; Industries; Religion; Amusements; Plays, Games; Education; Sickness and Death.

#### EVOLUTION. MAN'S ORIGIN. EARLY MAN

AS ORIGENS HUMANAS. By Mendes Corrêa (A. A.)—Repr. fr. *Medicina Moderna*; Porto, 1919, 23 pp.

The author gives the fundamental points of the neo-monogenistic doctrine as presented by Giuffrida Ruggeri, and follows with a critical discussion. He prefers it to the polygenistic doctrines, as they rely upon an obscure process of convergence and are in opposition to physiological data. He admits the verisimilitude of the hypothesis of Lull, which explains the passage from the *Pro-hominidae* to the *Hominidae* by climatic mutations brought forth by the rising up of Himalaya in the Tertiary.

M. C.  
UM PROBLEMA PALEOGEOGRAFICO. By Mendes Corrêa (A. A.)—Repr. fr. *Revista da Faculdade de Letras do Porto*; Porto, 1920, 15 pp.

Summing up the archeological and anthropological data about the problem of the Atlantis of Plato, the author comes to the conclusion that nothing proves the existence of any such continent within human era.

M. C.

ORIGIN OF THE SUPPOSED HUMAN FOOTPRINTS OF CARSON CITY, NEVADA. By Stock (Chester)—*Science*, May 21, 1920, 514.

"Many years ago the discovery of footprints, bearing a superficial resemblance to imprints made by a human foot, in a shale stratum exposed in the yard of the penitentiary at Carson City, give rise to the view that the existence of primeval man in Nevada was definitely established—a view that has taken a particularly tenacious hold. The possibility that the footprints were in reality those of a ground sloth, presumably of a form related to the South American *Mylodon*, was, however, advocated by Joseph Le Conte, O. C. Marsh and others. In 1917, the writer contrasted the outline of the so-called human footprints with that of a complete hind foot of *Mylodon harlani* reconstructed from remains of this species secured in the asphalt deposits at Rancho La Brea. The great resemblance which the articulated foot bore to the impressions, both in outline and in size, seemed certain proof that the latter were left by *Mylodon*.

The actual occurrence of osseous remains of *Mylodon* in the Pleistocene deposits at Carson City, Nevada, removed still farther the possibility that the Carson footprints are to be attributed to a member of the Hominidae and materially substantiates the suggestions of Le Conte and Marsh. Further, the presence of material referable to a mylodont sloth gives a high degree of probability to the contention that the footprints were made by *Mylodon* rather than by some other quadruped."

DIE MENSCHLICHEN KNOCHEN AUS DER HÖHLE FREUDENTHAL IM SCHAFFHAUSER JURA. By Schlaginhaufen (O.)—*Arch. Suis. d'Anthrop. gén.*, 1919, III, 275-299.

Description of 8 fragments of skulls, 1 complete and 2 fractured juvenile mandibles, 3 teeth, 3 vertebrae, 1 sacrum, and 1 fragment of the ilium of the Magdalénien period, from a cave near Schaffhausen, Switzerland. The specimens give the impression that they belonged to two different human types, the majority of them showing primitive conditions and a minority resembling recent Europeans. Among the primitive signs are the narrow shape of the alveolar arch in the mandible, the smooth, large fossa genioglossi, the extraordinary size of a number of teeth, and the high corpus of a lumbar vertebra relative to its width.

A. H. SCHULTZ.

#### HEREDITY, ATAVISM, SEX, ETC.

THE INHERITANCE OF ACQUIRED CHARACTERS. By MacBride (E. W.)—*Science Progress*, Lond., Jan. 1921, No. 59, 392-405.

The author quotes new evidence as to inheritance of acquired characters, and concludes that: "a very strong *prima facie* case for the inheritability of acquired characters has been made out, and that

no serious efforts have yet been made to combat the evidence. We are entitled to use the principle of use-inheritance in endeavoring to explain the facts of Palaeontology and Embryology, and when we do so, we find a flood of brilliant light thrown on these subjects, and a whole variety of puzzling phenomena become susceptible of rational explanation."

BASTARDIERUNG UND QUALITÄTSÄNDERUNG. By Schlaginhaufen (O.)—Repr. fr. *Natur & Mensch.*, Sept., 1920, Bern & Leipzig, 8 pp.

Recent results of various studies in heredity lead the author to believe that very likely in man also hybridization may cause changes in quality. In support of this a number of alleged facts are mentioned; for example, the findings by Boas, that the hybrids between whites and Indians surpass both parents in body height, and Hagen's observations concerning the greater face-height in a number of south Asiatic human hybrids. The small size of the different human pigmy "races" may be due to hybridization and may be looked upon as a domestication character.

M. C.

INWIEWEIT IST DER WURMFORTSATZ AM MENSCHLICHEN BLINDDARM EIN RUDIMENTÄRES GEBILDE? By Eggeling (H. von.)—*Anat. Anz.*, 1920, LIII, 401-428.

In recent literature the theory has been frequently advanced that the human vermiform appendix has an important function, and there are investigators who deny its rudimentary character. Von Eggeling reaches the conclusion, based on comparative-anatomical findings, that man's appendix developed from a much larger caecum in the human ancestors and that it is a rudimentary structure. The rich supply of lymph-nodules on the human appendix is, in the author's opinion, an indication that a change in function has taken place during its evolution. In prosimiae the caecum is large, and plays a role in digestion. The beginnings of an appendix are found in *Stenops* and *Chiromys*. None of the monkeys possesses an appendix; the caecum is relatively larger in platyrrhines than in catarrhines. With the exception of *Hylobates*, in which the appendix is small, this structure is larger in apes than in man. There are interesting tables on the lengths of the different portions of the intestinal tract in a large series of primates. An extensive bibliography adds to the value of the paper.

A. H. SCHULTZ.

UEBERRESTE DES SPHINCTER COLLI PROFUNDUS BEIM MENSCHEN. By Huber (E.)—*Anat. Anz.*, 1918, LI, 480-492.

Description of a fairly well developed musculus sphincter colli profundus on the left side of the neck of a white man. Rudiments of this muscle, which occurs regularly in *Prosimiae* and in *Hapalidae*,



have been found in man in only a very small number of cases, which are critically reviewed by the author.

A. H. S.

ZWIEGESTALT DER GESCHLECHTER BEIM MENSCHEN. By Fehlinger (H).—Leipzig, 1919, 48 pp.

Of this discussion of primary and secondary sexual characters in man the part dealing with secondary sexual differences in the various races is of special interest. It is pointed out that these are much less pronounced in primitive races and that in the latter it is often very difficult to distinguish the sexes by looking at the face. The chapter on sexual differences in growth just touches this problem and the one on sex determination and sex ratio is the indiscriminate collection of factors, unfortunately so often found, which are said to influence sex determination.

A. H. S.

SOME EARLY NEANTHROPIC TYPES IN EUROPE AND THEIR MODERN REPRESENTATIVES. By Fleure (H. J.).—*J. Roy. Anthropol. Inst.*, 1920, L, 12-40.

In this paper "the attempt has been made to study, both morphologically and geographically, a group of associated characters. It is found that they occur on the Plynlymon moorland and elsewhere in Wales, in Ireland, in France, in the Iberian peninsula, in Sardinia, in North and East Africa, among the Australians, in Fiji and in East Brazil. The other characters associated with them may, and do, vary considerably from region to region. These characters are shown to have occurred among Palaeolithic men (see list, pages 19-20) and the view is taken that we are dealing, in the modern populations, with survivals of a group of characters of high antiquity among peoples whose other characters vary too much for us to be able to speak of a common type. The possibility of some characters being outward and visible effects of changes of internal secretions and the like is borne in mind, but no speculations on this point are ventured. They would be irrelevant here.

It is noted that these survivals occur around the fringes of Eurasia and in the parts of America most remote from the pressure of immigrants from Asia. A map of the more or less open spaces above and around the forests in South America would bring this last point out very clearly.

A parallel study of survivals of Cro-Magnon and other ancient "grouped-characters" would probably be made, and Collignon and others have made suggestions on this point. \*

Granting the occurrence of a fairly early post-glacial spread of long-headed men, in all probability of several varieties including

"Combe Capelle," "Cro-Magnon" and others, we are able to picture to some extent the further evolution of characters in certain regions. The Baltic and West Mediterranean are chosen for special consideration because what are considered to be distinctive racial or subracial types are associated with these regions. The thought is pursued in this paper that the types in question show certain characters, evoked in the long run by environmental considerations, modifying various early forms of long-headedness and associated characters. The skulls, probably of Aurignacian date, listed on pages 19-20, are grouped together, with the Grimaldi Africanoid as a variant. The Cro-Magnon skulls and one skull from the Grotte des Enfants (Grimaldi) are probably another type. The Barma Grande (Aurig.) and Obercassel (Magd.) skulls suggest mosaics of these two groups. The Chancelade suggests intensification of some of our grouped characters and modification of others.

Skulls from Laugerie Basse, Sorde, Placard and Bruniquel, all Magdalenian or later, suggest modifications from our grouped characters towards the Mediterranean type, while several skulls from Solutré trend towards the Nordic type.

Skulls of dates undoubtedly later than the Palaeolithic are discussed in the preceding pages in so far as they suggest survival of our grouped characters.

Britain, as a region of refuge lying off the zone intermediate in position and in character between the Nordic and West Mediterranean areas of characterization, is supposed to show amongst its long-heads:

(a) Survivals of the old characters—"Combe Capelle" and probably Cro-Magnon, etc.

(b) Nordic immigrants.

(c) Mediterranean immigrants.

(d) Survivals of individuals who have not definite Nord or Mediterranean blood in their ancestry but represent descendants of people evolving from the stage (a) above to stage (b) or possibly (c).

(e) Doubtless some mixtures of (b) and (c). This is, of course, in addition to "broad-headed elements."

The paper makes interesting reading, and even though not fully conclusive, and suffering from certain weaknesses connected with the heterogeneity of the utilized material, is a step in the right direction in the study of at least a part of the post-Palaeolithic European and other populations. It is regrettable, however, that a generalization on America had to be made from insufficient data, which could not but lead to erroneous notions. The dolicho-hypsi-stenocephalic element shows a far wider distribution over the American continent, both south and north, than here supposed.

#### BIOLOGICAL RACIAL

NEUE ERGEBNISSE DER SCHIMPANSENFORSCHUNG. By Matschie  
(—) —*Zeitschr. f. Ethnol.*, 1919, LI, 62-82.

In the introduction the author points out that certain methods and viewpoints of the mammalogist could with advantage and should be employed by the physical anthropologist. Matschie's recent studies on Chimpanzees are based on 322 skulls and 159 skins. In the critique of the features, which have been claimed in the literature to distinguish the Chimpanzee from other apes, many new and interesting statements are found: The length of the arm varies to a great extent in the different species of Chimpanzee; there are forms in which the arm is as long as in many Orang-utans. The outer ear of the Chimpanzee is said to be larger than that of the Gorilla; this rule, however, has many exceptions; there are Chimpanzees whose ears are only 40 mm. long, and in Kamerun there is a Gorilla with ears at least 42 mm. in length even in the young animal. The crista sagittalis on the skull, often held to be typical for Gorilla, is missing in a great many females of this ape, and is found among the Chimpanzees in the Tschego and some species of the Congo and Ogowe regions. The nasal bones, which according to Keith, reach farther down in Gorilla than in Chimpanzee, are at times of greater relative length in the latter than in the former. The author finds that the Gorilla is distinguished from the Chimpanzee by the fact that the nasalia are more than twice as broad at their lower than at their upper ends, and also by the second last upper molar, which is at least 13 mm. in breadth and 12 mm. in length, while in Chimpanzee it is at most 12 mm. in breadth and 10 mm. in length. The rest of this paper is largely a discussion of the different species (races?) of Chimpanzee, including some new ones. The skull of a senile female Chimpanzee is described in which only the last upper molar of the right side remains, the alveoli of all the other teeth having disappeared and, as in senile man the lower jaw projecting beyond the upper one.

A. H. SCHULTZ.

ON THE INDEX CEPHALICUS AND THE ABSOLUTE DIMENSIONS OF THE HEAD OF THE POPULATION OF HOLLAND. By Bolk (L.)—*Proc. R. Acad.*, Amsterdam, 1920, XXIII, 103-110.

The cephalic index and the sum of length and breadth of head of nearly ten thousand inhabitants of Holland are studied according to their distribution in the different provinces. The provincial averages of the cephalic index oscillate between 79.6 and 81.5, the higher averages being found in the northeastern part of Holland where the Saxon element predominates, and the lower averages in the provinces with largely Frisian population. The latter has the smaller averages for the sum of length and breadth than the Saxon element, which has the slightly larger heads. The population of cities and even of smaller towns have a relatively narrower head than people living in the country, but the latter have somewhat larger diameters of the head than the former.

A. H. S.



ANTHROPOMETRISCHE UNTERSUCHUNGEN AN EINGEBORENEN IN DEUTSCH-NEUGUINEA. By Schlaginhaufen (O.)—*Abh. u. Ber. d. k. Zoolog. u. Anthrop.-Ethnogr. Museums*, Dresden, 1914, XIV, 1-82. (appeared recently).

This extensive anthropometric investigation is in a large part a careful mathematical analysis of the measurements taken by the author on four groups of natives of the northern part of New Guinea. One of the groups inhabits the Torricelli mountains, the other three the coast. The stature of the former group averages 150.9 cm. and those of the three coast groups average 158.2, 160.0, and 158.4 cm. respectively. A great width of the head and a great nasal height and width are characteristic for the group of small natives living in the mountains; all their absolute measurements, with the exception of the three just mentioned, fall below those of the coast groups. However, there are smaller differences between the proportions of the mountain tribe and one of the coast groups than between the different coast groups.

A. H. S.

FORME CRANICHE ESTRANEE ALLA VARIETA MEDITERRANEA IN ITALIA. By Sergi (G.)—*Riv. di Antrop., Atti Soc. Rom. di Antrop.*, 1917-18 (rec'd 1920), XXII, 1-16.

Professor Sergi calls attention to, and gives principal measurements of, a considerable number of crania from Sicily, Sardinia and various localities on the Italian mainland, which evidently belonged to members of other peoples than those of the Mediterranean strain. He also refers to a series of moderately microcephalic skulls, which he is inclined to consider as having belonged to a small statured race.

#### VARIATION—SOFT PARTS

DER GESICHTSAUSDRUCK DES MENSCHEN. By Krukenberg (H.)—*F. Enke*, Stuttgart, 1920, 2 ed., 328 pp.

This very thorough and richly and beautifully illustrated work on facial expressions, which is primarily intended for the artist, may be recommended to the anthropologist as well. The first part deals with peculiarities of feature as regards age, sex, and race, and includes also facial characteristics under abnormal conditions, such as starvation, micro- and hydrocephaly, idiocy etc. This is followed by a chapter on the development, physiology, and pathology of human facial expression in general. Special chapters on skin and hair, on eye, ear, nose and mouth, treat the influence and significance of changes in these parts on facial expression.

A. H. SCHULTZ.

#### ABSTRACT

BEITRÄGE ZUR ANTHROPOLOGIE DER GESICHTSWEICHTEILE DER

NEGER. By Zeidler, (H)—*Zeitschr. f. Morph. v. Anthrop.*, 1920, XXI, 153-184.

From the detailed study of the muscles of the heads of two Herero children and of one Hottentot child and from the literature, the author reaches the conclusion that the muscle fibres are more massive and various muscle groups are less easily differentiated in the negro than in the white. He considers as primitive the following conditions in the negro: The muscoli zygomaticus major and quadratus labii superioris are very massive and in the latter the three capita are hardly to be separated; the musculus quadratus labii inferioris is crossed and plaited over the chin; the muscles of the ear are very strongly developed.

A. H. S.

UEBER DAS HAUTLEISTENSYSTEM DER VOLA UND PLANTA DER JAPANER UND AINO. By Hasebe (K.)—*Arb. a. d. anatom. Inst. d. K. —Jap. Univ. z. Sendai*, April 1918, Heft 1, 13-88, pl. I-VII.

The work is based on the study of hand, foot and finger prints of 276 Japanese (215 males and 61 females) and 55 Aino (32 males and 23 females). The author finds: that as compared with the Ainos; "secondary altered conditions" of both palmar and plantar pattern are less frequent while "primitive conditions" are more frequent among the Japanese; that in the series of races so far investigated from this standpoint the Japanese occupy a middle position; that in both Japanese and Aino a more variable plantar pattern and a more primary palmar pattern obtain than among Europeans.

DAVIDSON BLACK.

SUR LES PROPORTIONS DES MEMBRES CHEZ LE FOETUS. Mendes Corrêa (A. A.)—Repr. from *Rev. Anthrop.*, Paris, 1919, 219-224.

The extent of individual variation in some of the relations between the segments of the fetal limbs prevents us from giving them any excessive importance for purposes of medical jurisprudence in the diagnosis of age. The radio-humeral and tibio-femoral indices do not vary regularly with age, though they are higher in the fetus than in the adult, in this way coming nearer to the anthropoids. As regards the humero-femoral, intermembral and clavio-humeral indices, their variation is more regular, and the more simian condition of the fetus better established. With the first, human condition is arrived at soon after birth, in the last only some years later. It is worth noting that some anthropoids have relatively shorter clavicles than the human fetus. These foregoing conclusions are based on the study of 16 fetal skeletons, ten of which were measured by the author.

SIZE OF THE EXTERNAL URETHRAL ORIFICE IN JAPANESE MEN. By Totsuka (R.)—*Jap. J. Derm. & Urol.*, 1918, XIX, No. 3, 10-32.

The study was based on examination of 1,029 laborers. The size of the orifice increases from the fifteenth to the twentieth year and corresponds to Charriere's number twenty-one to twenty-six. It remains constant from the twenty-first to the fortieth year, at number twenty-five to twenty-seven. The average number was twenty-six. But 3% were under number fifteen in size and 33% under number twenty-four. The average size of the orifice increased with the height. Those with height between 140 and 160 cm. corresponded to number sixteen to twenty-two; those over 160 cm. to numbers twenty-five to twenty-nine. Individuals with phimosis showed on the average a small orifice 60% taking a bougie less than number twenty-four. In hypospadias of moderate degree the orifice was larger than the average, but in men with second degree hypospadias, it was considerably narrower. The incidence of gonorrhoea was higher in men with wide orifices. In 5% of the men the valve of Guirin was narrow, in proportion to the size of the orifice corresponding to number three to four. This was usually in men with redundant prepuce, and a narrow external urethral orifice.

E. V. COWDRY.

DAS HAARKLEID EINES FETUS VON SCHIMPANSE. By Bolk (L).—*Bijdragen tot de Dierkunde*, Amsterdam, 1919, XX, 57-65.

A careful, detailed description of the hair, especially its direction, on a female fetus of Chimpanzee. The longest hair is found on the head in a region corresponding closely with the human scalp; the eyebrows and a beard are also well developed. The hair on the rest of the body is very short and can only be studied under magnification. There are bald areas on the nose and upper lip, over the sacrum, over the dorsal side of the carpus, and on each side of the perineum. The spots on the perineum are perhaps remnants of the callosities in monkeys. It is to be regretted that nothing is said about the size of this fetus.

A. H. SCHULTZ.

THE DEVELOPEMENT OF THE SYMPATHETIC NERVOUS SYSTEM IN MAN. By Kuntz (A.).—*J. Comp. Neurology*, 1920, XXXII, ii, 173.

"The primordia of the sympathetic trunks and the prevertebral plexuses arise from cells of cerebrospinal origin which advance peripherally both along the dorsal and ventral roots of the spinal nerves.

The vagal sympathetic plexuses, viz., the pulmonary, the cardiac, and the enteric plexuses, except in the aboral portions of the digestive tube, arise from cells of cerebrospinal origin which advance peripherally along the vagi. In the more distal portions of the digestive tube the enteric plexuses arise from cells which are derived from the sympathetic supply in the lower trunk region.

The majority of the cells which constitute the primordium of the ciliary ganglion are derived from the semilunar ganglion via the



ophthalmic nerve. Relatively few cells are contributed via the oculomotor nerve.

The cells which enter the primordium of the sphenopalatine ganglion earliest advance peripherally along the greater superficial petrosal nerve. The majority of the cells which enter the primordium of this ganglion are derived from the semilunar ganglion via the maxillary nerve and its rami.

The primordium of the otic ganglion arises at the growing extremity of the lesser superficial petrosal nerve as an aggregate of cells which advance primarily from the petrosal ganglion. The otic ganglion also receives cells of trigeminal origin via the mandibular nerve and its rami.

The submaxillary and sublingual ganglia arise on the lingual nerve primarily from cells of trigeminal origin. They probably receive some cells of facial origin via the chorda tympani.

The smaller sympathetic ganglia associated with the rami of the glossopharyngeal nerve in the posterior portion of the tongue arise from cells which advance into the tongue along the glossopharyngeal fibers.

The cells which give rise to sympathetic neurones are derived both from the cerebrospinal ganglia and the neural tube. Not all of these cells actually migrate as such from the cerebrospinal nervous system. Many of them arise by the mitotic division of migrant cells along the paths of migration and in the primordia of the sympathetic nervous system."

UEBER VERWANDTSCHAFTLICHE FORMBILDUNGEN AN BEIDEN ZUEINANDER GEHÖRENDE HEMISPHEREN. By Jatschewa (Z.)—*Arch. Suis. de Neurol. Psych.*, 1918, III, 3-14.

From a study of 20 human, 8 Chimpanzee, and some other mammalian brains the author concludes that the arrangement of the convolutions of the two hemispheres shows the principle of bilateral symmetry. In many brains there is absolute uniformity in the two hemispheres as regards the fissures and convolutions in certain regions. A deep convolution is frequently encountered on one hemisphere and a superficial one in the same place on the opposite side. At times corresponding convolutions in the two hemispheres form an angle at the same place, but in such a way that the bend of one is directed forward and the other backward.

A. H. SCHULTZ.

#### VARIATION—SKELETAL

UEBER METOPISMUS. By Bolk (L.)—*Zeitschr. f. Morph. & Anthropol.*, 1920, XXI, 209-226.

Among 1400 adult skulls from Amsterdam, metopism was found in 9.5 percent of the cases. The average cephalic index of the metopic skulls was 78.9 and of the entire material 78.3. Among the 23 skulls

with an index of only 71, metopism was present in 5 cases. This anomaly is therefore as frequent in dolichocephaly as in brachycephaly. The average length, breadth, and height of the metopic skulls are practically equal to the corresponding averages of the normal skulls. Bolk concludes from this fact that the brain volume of metopic skulls can not be larger than that of normal skulls and that therefore no increase in brain size can be responsible for metopism. He states later on that the average width of the forehead of his metopic skulls is considerably greater than that of normal ones. Direct measuring of the capacities in the two groups of skulls, which Bolk has not undertaken, would, most probably, have shown that the greater width of the forehead in metopic skulls increases their capacity, in spite of the fact that the three main diameters are equal to those of normal skulls. The author advances the theory that the closure of the metopic suture is the result of the transverse pressure exerted by the temporal muscles on the cranial vault, which the latter withstands by a system of trajectories arranged on a frontal plane. These trajectories can not be interrupted in the median line and lead to the fusion of the frontal bones. This fusion is with but few exceptions, found in monkeys and apes, where the temporal muscles insert to a great extent on the frontal bones. In man this muscle covers only a small part of the latter bone so that the muscle pressure loses its significance and metopism may again occur as in most prosimiae in which the temporal muscles do not reach the frontale. If we accept this theory of Bolk, it is difficult to understand why the sagittal suture is not closed by the same influence, inasmuch as the temporal muscles would certainly exert greater pressure on the parietal bones, which they cover to a greater extent than the frontal bones. Furthermore it seems that if the temporal muscle has any functional influence at all it would also have one of muscle pull, which would tend to pull the frontal bones apart. In a footnote the author states that among 20 recently acquired skulls of gorillas he found the frontal suture entirely open in one female with complete dentition—probably the first known case of metopism in the anthropoid apes.

A. H. SCHULTZ.

UEBER PRAEMATURE OBLITERATION DER NÄHTE AM MENSCHENSCHÄDEL. By Bolk (L.)—*Zeitschr. f. Morph. & Anthropol.*, 1919, XXI, 1-22.

The examination of 1820 infantile and juvenile skulls from Amsterdam shows that premature synostosis of sutures is much more frequent than has been generally believed. In 18.8 percent of these skulls one or more sutures were completely or incompletely obliterated; in 14.8 percent the masto-occipital suture was more or less closed and in 13 percent this suture was the only one obliterated. Premature synostosis occurs as early as the 5th year and is found in

about equal frequency at all ages up to the 12th year. The sagittal suture was obliterated in 3.8 percent of all the skulls, and in 1.6 percent of those with only milk dentition. From the 6th to the 12th year an obliterated sagittal suture was found with practically constant frequency, i. e. in 3 to 4 percent of the cases. In anthropoid apes the sutures close very early, especially on the brain part of the skull, where obliteration takes place before growth is completed. In oranges one frequently finds the occipito-sphenoidal synchondrosis wide open and the sutures of the brain case obliterated. The persistence of the sutures in modern man is a condition which has arisen only comparatively recently and under the influence of the strong development of the brain. The author considers premature synostosis in man as an atavism and only in rare cases as due to rickets or syphilis, of which diseases he found no traces in his skull material.

A. H. S.

DER UNTERKIEFER DES CHINESEN. By Kurz.—*Arch. f. Anat. & Physiol.*, anat. Abt., 1919, Jahrg. 1918, 173.

Based on a great number of measurements and on the weights of only a few Chinese mandibles. The author finds 30 points of distinction between the Chinese and whites. He considers the following as primitive signs of the Chinese mandible: the great weight of the mandible; the great height of the corpus mandibulae; the broad and low ramus, and the little development of the protuberantia mentalis.

A. H. S.

UNTERSUCHUNG DES STERNUM UND DER RIPPEN EINER 25 JÄHRIGEN CHINESIN. By Kurz.—*Arch. f. Anat. & Physiol.*, anat. Abt., 1919, Jahrg. 1918, 210.

A detailed description of the sternum of one Chinese woman measuring, without the xyphoid process, only 115 mm. in length.

A. H. S.

UNTERSUCHUNGEN ÜBER GROSSEN-UND FORMVERHÄLTNISSE DES ZUNGENBEINES UND DES KEHLKOPFSKELETES EINER 25 JÄHRIGEN CHINESIN. By Kurz.—*Arch. f. Anat. & Physiol.*, Anat. Abt., 1919, Jahrg. 1918, 216.

A short study of the hyoid and of the larynx—especially of its cartilages—of a Chinese woman. There are a number of slight differences in these structures when compared with the corresponding parts of whites.

A. H. S.

UEBER MUSKELINSERTIONEN UND URSPRUNGE AM UNTERKIEFER; EIN BEITRAG ZUR KINNFRAGE. By v. d. Broek (A. J. P.)—*Zeitschr. f. Morph. & Anthropol.*, 1920, XXI, 227-284.

In this comparative anatomical study the author gathers from the literature and contributes a great deal to our knowledge of the muscle



insertions on the mandible of primates, including man. An apophysis lemurica on the angle of the lower jaw results from the insertion of the masseter muscle, which may reach around the lower border to the medial side of the mandible, thus causing a furrow on the basis mandibulae. This furrow gives the posteriorly lying angle the form of an apophysis. The latter is found also on the mandible of many primates. There is a good review of the different theories regarding the origin of the chin, including the recent attacks by Fischer and Weidenreich on Walkhoff's theory. The author believes the chin to be due to typically human conditions of muscles and to have developed in answer to muscular pull.

A. H. S.

THE HISTORY OF THE EARLIEST STAGES IN THE HUMAN CLAVICLE.  
By Hanson (Frank Blair)—*Anat. Rec.*, 1920, XIX, No. 6, 309-326.

The literature on the human clavicle contains three theories of clavicular origin: it has been thought to be a purely cartilage bone; a purely dermal bone, and also to be a mixed element, containing both cartilage and dermal contributions. Since the latest paper on the subject (1918) attempts to resuscitate the theory advanced in the earliest paper on the subject (1864), the whole question is opened again to reinvestigation.

The material at the author's command, the Mall Collection, than which there is no better or larger collection of human embryos anywhere to be found, confirmed in all essential particulars the view that the clavicle ossifies in its first stages as a purely dermal element, to which cartilage is added later, but without morphological significance. Ossification begins approximately about the thirty-ninth day and is by two distinct centers, one in the lateral half and one in the medial half of the clavicle. At this time the bony centers are surrounded by the "peculiar precatilaginous tissue" (of Mall), which is not hyaline cartilage. It seems quite clear that *the earliest stage of ossification* in the clavicle, both in its medial and lateral halves, *is a dermal ossification*, and that cartilage is entirely lacking at the time of the appearance of the two centers of bony tissue.

It seems to be pretty well established that the coracoid process of placentals is a precoracoid, so that this bone is fully accounted for without reference to the clavicle. It might be suggested that the part of the precoracoid which has aborted is the piece found in the clavicle, but it has been shown clearly that the clavicle is fully formed and contains its maximum amount of cartilage long before the degeneration of the precoracoid, i. e., the fully formed precoracoid extending from scapula to sternum persists for a considerable time after the ossification of the clavicle has begun and the cartilage at its ends is present. The two, fully formed clavicle and precoracoid, are in marsupials coexistent and separated by a considerable space. There is,

therefore, no way for the cartilage of the precoracoid to enter the clavicle in mammals.

F. B. H.

THE PROBLEM OF THE CORACOID. By Hanson (Frank Blair)—*Anat. Rec.*, 1920, XIX, 327-346, No. 6.

The coracoid process of man presents one of those problems of vertebrate phylogeny upon which the last word has not yet been said.

This paper is an attempt to carry the homology of the coracoid process back through a series of living and extinct forms to the Permian reptiles from whence in all probability the mammals arose.

It has been shown by Broom for Australian marsupials and the author for the American opossum that in the embryo and fetus, the shoulder-girdle consists of a scapula, a clavicle, and two coracoid elements, one of which, the posterior extends from the scapula to the sternum and is comparable directly with the coracoid of monotremes. The anterior element of the marsupial fetus is a broad fan-shaped sheet of mesenchyme, of short duration in embryonic life, and is the homologue of the epicoracoid of monotremes.

Development shows that the posterior of the two coracoidal elements of the fetal marsupial girdle becomes the small coracoid process attached to the scapula in the adult, which process undoubtedly is homologous with the same-named process in man. This gives a clear line of relationship from the coracoid process of man to the posterior element in the girdle of the monotremes, by way of the transient coracoid in the marsupial fetus.

The author and others have maintained that the conditions in the monotreme girdle are so clearly reptilian in character and approximate so closely in every respect to the structure of the girdles in *Sphenodon* and the lizards, that genetic relationship and homology exists between them.

Williston has practically demonstrated that the coracoid of living reptiles is derived from the anterior bony element (precoracoid) of Permian reptiles.

Therefore, if the coracoid process of man is the same element as the posterior coracoid of monotremes, and this latter is directly comparable with the posterior of the two coracoids of *Sphenodon* and lizards, which is in turn a derivative of the precoracoid of Permian reptiles, then the coracoid process of man equals the anterior bony element of Permians, and *the precoracoid is the true coracoid*. . . .

F. B. H.

OSTEOMETRIA PORTUGUESA—II—CINTURA ESCAPULAR. Mendes Corrêa (A. A.)—Repr. fr. *Anaes da Acad. Politec. do Porto*. Coimbra, 1919, 45 pp.

Based on study of parts of some scores of Portuguese skeletons of either sex well identified. The left clavicle is on the average longer

than the right, and the male bone is somewhat more curved than the female. The clavio-humeral index is slightly higher than the figures established by Broca and Pasteau for other branches of whites; author is of the opinion that this index does not clearly distinguish the whites from the negroes. In the scapula, the scapular notch of the Portuguese is generally less deep than in the whites of America (according to Hrdlicka's data). Sexual differences are especially marked in the height of the bone, in the breadth of the acromion, and the glenoid cavity. The spino-acromial index as well as that of the glenoid cavity are larger in the males than in the females and the scapular index approaches the average given by Livon for the whites in general.

FORMVERSCHIEDENHEITEN AM KÖRPER DES MENSCHLICHEN BRUSTBEINS UND IHR MORPHOLOGISCHER UND KONSTITUTIONELLER WERT. By Lubosch, (W.)—*Gegenb. Morph. Jahrb.*, 1920, LI, 91.

The examination of 190 white sterna and the consideration of the literature on sterna lead the author to the following conclusions: The variations of the human corpus sterni are the consequence of a mixture of two types of this bone. These he calls the "primatoid" and the "hominid" type respectively; the latter is more than twice as frequent as the former. The primatoid is a long and narrow sternum with an approximate average of 29 for the index:

$$\frac{\text{breadth of corpus sterni}}{\text{length of corpus sterni}} \times 100.$$

In the hominid type this index lies between 50 and 60, which indicates the extreme broadness of this class of corpora sterni. In the former type the costal cartilages are inserted in incisurae costales, whereas in the hominid type these cartilages are attached to regular costal "processes." In the primatoid type there exists a tendency of the first segment to remain separate, and there are frequent indications of a sagittal division. In the hominid type there is a tendency for bony fusion between corpus and manubrium sterni. Fetal sterna show the same range of variation as regards their relative breadth as found in adult sterna. In the author's opinion, the dimorphism in human sterna is due to hereditary influences, as it can not be explained on the grounds of age, sexual, or functional differences. In the comparative anatomical part of this paper it is pointed out that the orang, with his extremely broad sternum, is distinguished in this respect from all other mammals. There is a good and extensive bibliography.

A. H. SCHULTZ.

DIE VERSCHIEDENEN FORMEN DER WIRBELSÄULE DES MENSCHEN UND IHRE BEDEUTUNG. By Rosenberg (E.)—1st part. *Jena*, 1920, 163 pp.

This spacious work deals in detail with the different types of the human spine and their significance. The author collects here the essen-



tial parts of his numerous publications on this subject, endeavors to refute the objections of his many adversaries, and adds a great deal of new proofs to his hypothesis of the proximally advancing changes in the spine. Special attention is paid to the transition vertebrae at the borders of the different spinal regions. Among the author's theories may be mentioned that the lumbar vertebrae originate successively from dorsal vertebrae, the present first lumbar being the last vertebra thus transformed and showing not infrequent signs of this process. In a similar way the sacrum develops from lumbar vertebrae, making the fifth sacral vertebra the oldest one. The first vertebra of the sacrum is at times found as a lumbosacral vertebra—a retarded condition,—i. e. the processus lateralis on one side does not fuse with the pars lateralis; the opposite condition—an acceleration—, i. e. the 24th vertebra as a lumbosacral vertebra is not a very rare finding and connected with it a double promontorium may occur. On the sacral-caudal border the last sacral vertebra may show signs of transformation into a caudal vertebra; or, on the other hand, the 30th vertebra (normally 1st caudal one) may be a sacrocaudal vertebra, which would be an atavistic condition. In the discussion of the reduction in the dorsal spinal region the ribs are brought into consideration, especially the number and proportional length of those indirectly attached to the sternum and of the floating ones. According to the author, early embryos as a rule have the anlage of a 13th pair of ribs.

An extensive bibliography and a number of beautiful plates augment the value of this book.

A. H. S.

OSTEOMETRIA PORTUGUESA—III—CINTURA PELVICA. — Mendes Corrêa (AA.)—Repr. fr. *Anaes da Acad. Polit. do Porto*, Coimbra, 1920, 16 pp.

The innominate bones in the Portuguese series studied by the author are narrower and higher than generally in the other branches of the white race. Sexual differences are like those noted in other human series. Broca's pelvic index is as usual higher in the females than in the males, nevertheless there are some differences from other European series. The study of Sergi's ileo-pelvic index confirms the stronger narrowing downwards of the male pelvic cavity. The index of the superior strait is higher in the females than in the males, but given the fluctuations of this index the results are not easily comparable with those obtained on other peoples.

L'ÉPIPHYSE INFÉRIEURE DU FÉMUR CHEZ LES PRIMATES. Vallois (Henri V.)—*Bull. & Mém. Soc. Anthropol. Par.*, 1919, X, 21-45, 80-107.

Painstaking study, dealing with the robustness of the distal extremity of the femur; the femoro-biepicondylar index; the femoro-condylar external index; and the angle of inclination or divergence of the bone, in man and the Primates in general. The biepicondylar index

stands in inverse relation to the agility of the form studied, being largest in the bones of the most sluggish and smallest in those of the most active species. The angle of divergence of the femora presents a series of interesting features. It is greater in the female than in the male; greater in the adults than in the young; and considerably greater, due to his biped habit and larger pelvis, in man (and the *Pithecanthropus*) than in any of the other Primates.

UEBER TORSIONERSCHINUNGEN AN DEN LANGEN RÖHRENKNOCHEN DES MENSCHEN. By Grünewald (J.)—*Zeitschr. f. Morph. & Anthropol.*, 1919, XXI, 103-150.

An extensive historical review of the controversy regarding the different theories on torsion and rotation of the limb bones of man is followed by a rather complicated discussion of the torsion of humerus, femur, and tibia. Much space and a good deal of theoretical speculation are devoted also to the question of the forces which cause these torsions. Besides the primary rotation of the extremities, a secondary torsion takes place after the middle of intrauterine development. Originally the caput humeri points backwards, its axis forming an angle of approximately 90 degrees with the axis of the elbow joint. Later the caput turns medially, so that in the adult the axis of shoulder and elbow joints are nearly parallel (average divergence 12 degrees). These changes follow the turning of the shoulder blade. In regard to the femur, the pelvis plays a rôle similar to the scapula for the humerus. The acetabulum, by moving out of a sagittal towards a frontal plane, takes the caput femoris with it, so that the latter shows during the entire period of growth a tendency towards retroversion. On the shaft of the femur signs of twisting under the influence of the rotating muscles are found, e. g. the rolling up of the spongiosa in the upper third of the shaft. The retroflexion of the collum femoris and the retroversion of the caput are typical for man.

A. H. SCHULTZ.

#### VARIATION—PHYSIOLOGICAL

THE METABOLISM OF THE EUNUCH. By Read (Dr.)—Report to appear in the *Jo. of Biol. Chemistry*.

Analysis of the urine of the Eunuch showed eccentric ammonia values and demonstrated a deranged metabolism. Creatin was found in all cases in which the patient underwent operation before the full development of secondary male characteristics. A short summary of some of the physical changes in the Eunuch showed that the secondary sex characters followed along chemical as well as physical lines for the eunuch shows definite female characters.

AUTHOR'S ABSTRACT.

BLOOD PRESSURE IN HEALTHY JAPANESE. Takenura (I.)—*Kyoto Igaku Zasshi (Kyoto J. Med. Sc.)*, 1918, XV, 84-126.

The author studied the blood pressure of 3,942 individuals (2,842 males, 1,100 females), who were between the ages of 4 and 25 years. He used a von Recklinghausen tonometer, reading by Korotkow's auscultatory method. Results were recorded in cm. of water.

The normal pressure at 4 years was 98/67 in boys and 94/65 in girls. It rose gradually to 165/112 in men of 19 and to 151/101 in girls of 18, practically the normal adult figures.

The pulse pressure rose from 31 cm. (male), 29 cm. female at 4 years to 54.5 (male), 50.5 (female) at the ages of 19 and 17 years respectively.

The average height was 93 cm for boys; 90.2 cm. for girls of 4; 160.3 cm. for boys of 19, 148.4 cm. for girls of 18, practically adult figures. The body weight was 13.6 kg. for boys of 4; 12.9 kg. for girls of 4; 54.1 kg. for men of 21; 48.4 kg. for girls of 20.

The annual increase in the blood pressure was particularly marked in boys from the 13th to 17th years; in girls from the 12th to the 15th years (puberty).

The average blood pressure, as well as average height and weight, was higher in girls of 13 to 15, than in boys of the same age.

In general the curve of rising blood pressure ran parallel with those of body height and weight.

The author expresses the variability as follows:

Average value: boys, 170.13; girls 152.3.

Variation from standard; boys, + 18.05; girls, + 13.71.

Coefficient of variation: boys, + 10.6; girls, + 9.0.

SEVERANCE REVIEWS, 1920, V, No. 5.

#### DEMOGRAPHY

#### CHINA'S P. O. CENSUS:

##### POPULATION OF 427,679,214 SHOWN OUTSIDE OF MONGOLIA AND TIBET

The Chinese Post Office has lately collected figures from the various hsien, or administrative units of the republic, and from these has been compiled an estimate of population which, though only an approximation, probably represents the most reliable information to be had on the subject. The "400,000,000 of China" has become a familiar expression, adding force to many an argument and emotion to many an appeal.

It is interesting to note that the expression has the figures of the Post Office estimate as well as the sanction of good usage to back it up. The returns, which were obtained through the Postmasters of the various hsien, were much more nearly complete than might have been expected in so large and disorganized a country. Mongolia and Tibet were excluded entirely, besides which the only exceptions from the estimate were one hsien in the Peking district and three in Man-



churia. With these exceptions, the Post Office figures put the total population of China at 427,679,214.

China has never had a census of the Western sort, and consequently estimates of population have varied widely. The so-called census taken by the Ministry of the Interior (Minchengpu) in 1919 furnished figures which have been regarded as the most reliable. With few exceptions, however, families were counted and not individuals, and an average was carefully worked out for the sake of arriving at the approximate number of persons. The multiple was 5.5, except for the province of Fengtien in Manchuria, where it was set at 8.38 per family.

Thus the total population of the eighteen provinces of China proper and the three Eastern provinces of Manchuria was calculated at 331,188,000. When Sinkiang, Tibet, the dependencies and the Manchu military organization were counted in, the number was brought to 342,639,000.

The figures as given by the Post Office estimate for the various provinces look like those of important independent States rather than only parts of one vast republic:

Province	Total Pop.	Pop. per Sq. M.
Anhui .....	19,832,665	337
Chekiang .....	22,043,300	600
Chihli .....	34,186,711	294
Fukien .....	13,157,791	284
Honan .....	30,831,909	454
Hunan .....	28,443,279	341
Hupeh .....	27,167,244	380
Kansu .....	5,927,997	47
Kiangsi .....	24,466,800	353
Kiangsu .....	33,786,064	875
Kwangsi .....	12,258,335	158
Kwantung .....	37,167,701	372
Kweichow .....	11,216,400	167
Shansi .....	11,080,827	134
Shantung .....	30,803,245	550
Shensi .....	9,465,558	125
Szechuan .....	49,782,810	228
Yunnan .....	9,839,180	57
Manchuria .....	13,701,819	37
Sinkiang .....	2,519,579	182

The Post Office estimate gives some startling statistics on density of population. Shantung has generally been regarded as the most crowded, being so listed by the Minchengpu census. The Post Office estimate, however, puts the province of Kiangsu in the lead, with 875 to the square mile, while Chekiang stands second, with 600, and

Shantung third, with 550. Hereafter, when the idea of density of population is to be emphasized, Kiangsu, doubtless, will be referred to instead of Belgium.

N. Y. TIMES, DEC. 5, 1920.

COMPARATIVE HUMAN PATHOLOGY & TERATOLOGY

PHYSICAL EXAMINATION OF THE FIRST MILLION DRAFT RECRUITS: METHOD AND RESULTS. Compiled by Love (Albert G.) & C. B. Davenport, under the direction of the Surgeon General, M. W. Ireland, Maj. Gen. Med. Corps, U. S. Army. War Dept.: Office Surgeon General, *Bulletin, No. 11*, Wash., March, 1919, 521 pp.

This is a report on the methods and results of the physical examination of the first million draftees who reported to camps, September 1917 to May 1918. The report does not pretend to give statistics as to the kinds and relative frequency of occurrence of defects in the American population, nor is it an anthropological study of the recruits. Especial stress is laid on the standards of the physical examination, how they varied and some of the consequences of the varying standards on the physical qualities of our Army.

Of the physical examination standards published for the use of medical examiners, we had no less than seven during the period of the War. These standards were made successively more liberal from July 1917 to February 1918, and thereafter were made somewhat more strict for men accepted for general military service, indicating that experience showed that nothing is gained by accepting larger numbers of recruits at the expense of the necessary physique.

As for data of anthropological, biological and general medical interest, the report yields many. Flat foot is the greatest defect found in men who reached camp. There was much more of it in northern than in southern recruits; more in recruits from urban than from rural districts. This and collateral facts prove that the prevailing foot defects are largely due to fashionable shoes. Altogether, over a fifth of the draftees had defective feet. Fashionable shoes might conceivably cause the military defeat of a nation. It is patriotic for men to wear roomy shoes, or, none at all! Hernia is the next most serious defect in recruits, from a military point of view. It is probable that there is a biological factor present in both bad feet and hernia; namely, a failure of the parts concerned to meet fully the needs of the species, namely, of plantigrade locomotion, especially under the handicap of fashionable shoes, and of the upright position.

Some stress is laid in the report on the geography of disease and defects. Thus, goitre is strikingly common in the Great Lakes region and the extreme northwest, probably on account of the limestone there. Tuberculosis is commonest in the southwest, the natural sanatorium to which persons with "weak lungs" have migrated. Venereal disease is commonest in the South, because much commoner among

negroes than whites. Incidentally recruits from cities showed less venereal disease than those from rural districts.

Generally considered, it appeared that between one-third and one-fourth of our young men aged 20 to 30 years were not fit to fight. But that does not say between one-third and one-fourth are seriously handicapped for civil life. Many a man has profoundly affected the mores of a people who would have been a failure as a stevedore.

The work contains 22 large tables in the appendix. These treat of such matters as: Frequency in recruits, from each State, of defects that were sufficient to cause rejection and minor defects that did not prevent acceptance for general military service. The role that the medical advisory board played in the selection of recruits. The changes in ideals of examiners month by month as the War progressed. Defects from cities and rural districts, and, particularly, the defects found in recruits from New York, Chicago, Philadelphia and Boston.

The report leaves much unanswered about defects in the American population as it comes, unselected. A study of defects in two million draft recruits and half a million men rejected by local boards is promised in the near future.

DER WELTKRIEG UND SEIN EINFLUSS AUF DEN WEIBLICHEN ORGANISMUS. By Müller (P.).—Bern, 1918.

From this collection of the obstetrical and gynecological literature dealing with the influence of the past war on women, the chapters on growth and sex of fetuses and newborns are of interest to the anthropologist. According to all reports undernourishment of mothers due to war conditions had little or no influence on the size of newborns and unusually large babies were just as frequent after 1914 as before that time. No uniformity, however, exists in the different papers referring to the proportion of the sexes at birth during the war, some claiming an increase in male births, others denying this. In another chapter it is shown that the duration of lactation has increased in war times. Chemical analysis of the milk of undernourished mothers shows no difference from that of well nourished mothers.

A. H. SCHULTZ.

INFANT MORTALITY (in New Bedford, Mass.). By Whitney (Jessamine S.).—*U. S. Children's Bur. Publ. No. 68, 8°*, Wash., 1920, 114 pp.

How industrial conditions affect a baby's chance of living beyond its first year is described in this report. Unskilled and semi-skilled occupations predominate in the cotton industry, and at the time the survey was made, wages were low. A low income was accompanied, as in other industrial cities studied by the Bureau, by poor home sanitation, congestion, lack of adequate medical care, and a mother who was overworked, either in the factory or at home. Over half of the New Bedford babies lived in the river section where the worst living



conditions in the city were to be found. There families of from 15 to 18, including lodgers, were in many cases crowded together in 5-room tenements. Practically all the mothers working in the cotton mills of New Bedford were in families where the father earned less than the amount necessary to maintain a decent standard of living. Almost half of all the mothers were gainfully employed, chiefly in the cotton mills, during the year before the baby was born, and two-fifths during the year following the baby's birth. Most of these mothers worked during both periods. The harmful results of depriving a young baby of its mother's care and nursing is shown in the fact that among the babies whose mothers left them to go out to work when the baby was less than 4 months old, the mortality was nearly twice the average rate. The low income group showed a high mortality rate while the group having incomes sufficient to insure proper care and surroundings for the mothers and babies had a low mortality rate. In the low wage group 20 babies out of every hundred born alive, died before the end of the first year. In the highest wage group only 6 out of every hundred babies died.

INFANT MORTALITY (in Akron, Ohio). By Haley (Theresa S.)—*U. S. Children's Bur. Publ. No. 72, Wash., 1920, 8°, 118 pp.*

In the year selected, the infant mortality rate in the city was 86 per thousand births. As compared with other industrial cities studied by the Bureau, Akron had a relatively low rate. But even this rate of 86 is considerably higher than rates already reached in New Zealand cities; as in Dunedin, where the rate is only 46. This report gives further evidence of the fact shown in previous studies of infant mortality made by the Bureau that as fathers' earnings increase, the infant mortality rate falls. The death rate in families where the fathers' earning were not sufficient to provide medical and nursing care, and other essentials for the care of children during infancy was much higher than in families with larger incomes. The mortality among children of native mothers was much lower than among babies of foreign born mothers, especially in digestive and in respiratory diseases. The death rate among babies who were artificially fed was found to be over four times as great as among those who were breast fed. The study, which was made before Ohio was admitted into the Birth Registration Area, revealed an imperfect birth registration. A thorough canvass of the city made in connection with the study showed that about 14 per cent of the births were not registered. Since the time of the study, the report shows, great improvements have been made in the facilities of the city health department. New infant welfare stations have been opened, and the number of visiting nurses increased. The report points out, however, that further increases in these facilities are needed for the adequate health protection of Akron's babies and mothers.

## NOTES

A department of Anthropology has recently been established in the University of Bristol, England, under the Department of Anatomy, and students of the department who are undergraduates, and have fulfilled the necessary conditions, may include the subject of Human Morphology and Anthropology in the subjects for the Final B. Sc. Examination. Miss M. A. Czaplicka, who has been appointed Lecturer in Anthropology, is at present organizing the Department, and giving a series of Preliminary Lectures in Ethnology, weekly. Two lectures have already been given on Siberia and a third is to be given on the Turks in Central Asia.

The newly organized (post-graduate) School of Diplomacy, Jurisprudence and Citizenship, at the American University, Washington, D. C., includes a course in Anthropology, by Dr. Ales Hrdlicka, on Man's Evolution, Differentiation and Spread, and on the Racial Origins and Composition of the various Nations.

At the annual meeting of the Carnegie Institution of Washington the Station for Experimental Evolution and the Eugenics Record Office at Cold Spring Harbor, without loss of their identity were, for administrative purposes, combined into the Department of Genetics, with C. B. Davenport, director of the department, Dr. C. C. Little assistant director for the Station, and Dr. H. H. Laughlin assistant director for the office. Professor Harold D. Fish, now of the University of Pittsburgh, was reappointed research associate of the department of genetics.

The thirty-seventh session of the American Association of Anatomists was held at the Wistar Institute, Philadelphia, March 24-26. The rich program, while essentially biological, included a number of communications of anthropological nature or interest. The main of these were: *On Monozygotic Human Twins*, by L. B. Abey; *The Morphologic Index*, by R. B. Bean; *The Growth of the External Dimensions of the Human Body in the Fetal Period*, by A. L. Calkins; *On the Torsion of the Developing Femur*, by E. J. Carey; *The Growth of the Brain and the Spinal Cord in the Human Fetus*, by H. L. Dunn; *Functional Variation of the Normal Human Mammary Gland*, by J. McFarland; *The Percentage of the Organic Content of Human Bones at Different Ages*, by H. E.

Radasch; *On the Growth in Weight of the Human Body and its Various Parts and Organs in the Fetal Period*, by R. E. Scammon; *A Well-preserved Human Embryo of the Presomite Period*, by G. L. Streeter; *The Order, Time and Rate of Ossification of the Mammalian Skeleton*, by R. M. Strong; and *Mammalian Pubic Metamorphosis*, by T. W. Todd.

During the latter part of December, 1920, a British Expedition had left Peking for Tibet. The expedition was headed by Captain Eve and Major White, both of the British Army. They have both been on exploring expeditions in the Altai region before and are by no means beginners in the work. Major White has just returned from an expedition to Timbuctu. Captain Eve is a British subject born in Russia, and was in charge of the British Forces operating about Baku during the war. The main object of the expedition is to make a thorough study of some special points in the geology of Tibet, but some attention will also be given to the population.

A conference under the joint auspices of the Divisions of Medical Sciences and Anthropology and Psychology to consider the offer of facilities for research by the Child Welfare Society and the Woman's Welfare Association was held at the National Research Council, Wednesday evening, January 19, 1921, at eight p. m. A suitable resolution was adopted calling to the attention of scientific men in the capital the facilities thus offered.

WEIGHING AND MEASURING OF CHILDREN. To establish a standard table of the heights and weights of children a conference of representatives of the U. S. Children's Bureau, the U. S. Bureau of Education, the U. S. Public Health Service, and of various educational and private organizations working for the betterment of children, has recently been held in New York City.

At the present time various tables of measurements are in use by the different organizations engaged in weighing and measuring children. The results of the tests are not comparable; also considerable confusion has arisen because of apparent differences in the standards of normal development as given out by the various organizations. The conference brought out the fact that the various tables are in substantial agreement as to fact, the differences being chiefly matters of presentation.



A complete standard table will be prepared by a committee, and all future weighing and measuring of children can then be in accordance with this uniform table. The findings of the tests will be comparable and much greater use can be made of the facts revealed.

The conference was attended by the following: Dr. Bird T. Baldwin, Iowa State University; Dr. Taliaferro Clark, U. S. Public Health Service; Dr. William R. P. Emerson, Nutritional Clinic for Delicate Children; Dr. L. Emmett Holt, Child Health Organization; Mr. Ira V. Hiscock; Mr. Frank A. Manny, Nutritional Clinic for Delicate Children; Dr. Anna L. Rude, U. S. Children's Bureau; Mr. Edgar Sydenstricker, U. S. Public Health Service; Prof. Edward L. Thorndike, Columbia University; Mrs. Ira Couch Wood, Elizabeth McCormick Memorial Fund; Dr. Thomas D. Wood, Columbia University; Dr. Robert M. Woodbury, U. S. Children's Bureau.

SCIENCE. N. S. Vol. LIII, No. 1363, 136, 137.

Six Hunterian lectures on the "Principles of Human Craniology," illustrated by specimens and preparations, were delivered by Professor Arthur Keith at the Royal College of Surgeons, during January.

The trustees of the American Museum of Natural History have created a new department designated as Comparative Anatomy and have appointed Dr. William K. Gregory to the curatorship as a recognition of Dr. Gregory's contributions to anatomy and vertebrate paleontology, which have been largely carried on at the museum during the 22 years that he has been connected with it. Dr. Gregory will have associated with him in the new department Dr. J. Howard McGregor, who has been appointed associate in Human Anatomy.

Dr. Ernest Albert Hooton has been appointed assistant professor of anthropology at the Harvard Medical School.

Yale University has granted leave of absence for 1921-1922 to Professor George Grant MacCurdy, who has been elected first Director of the recently established American Foundation in France for Prehistoric Studies.

At the Galton Anniversary Meeting, February 16, the "Galton Lecture" was given by Professor W. Bateson, who spoke on "Common Sense in Racial Problems."

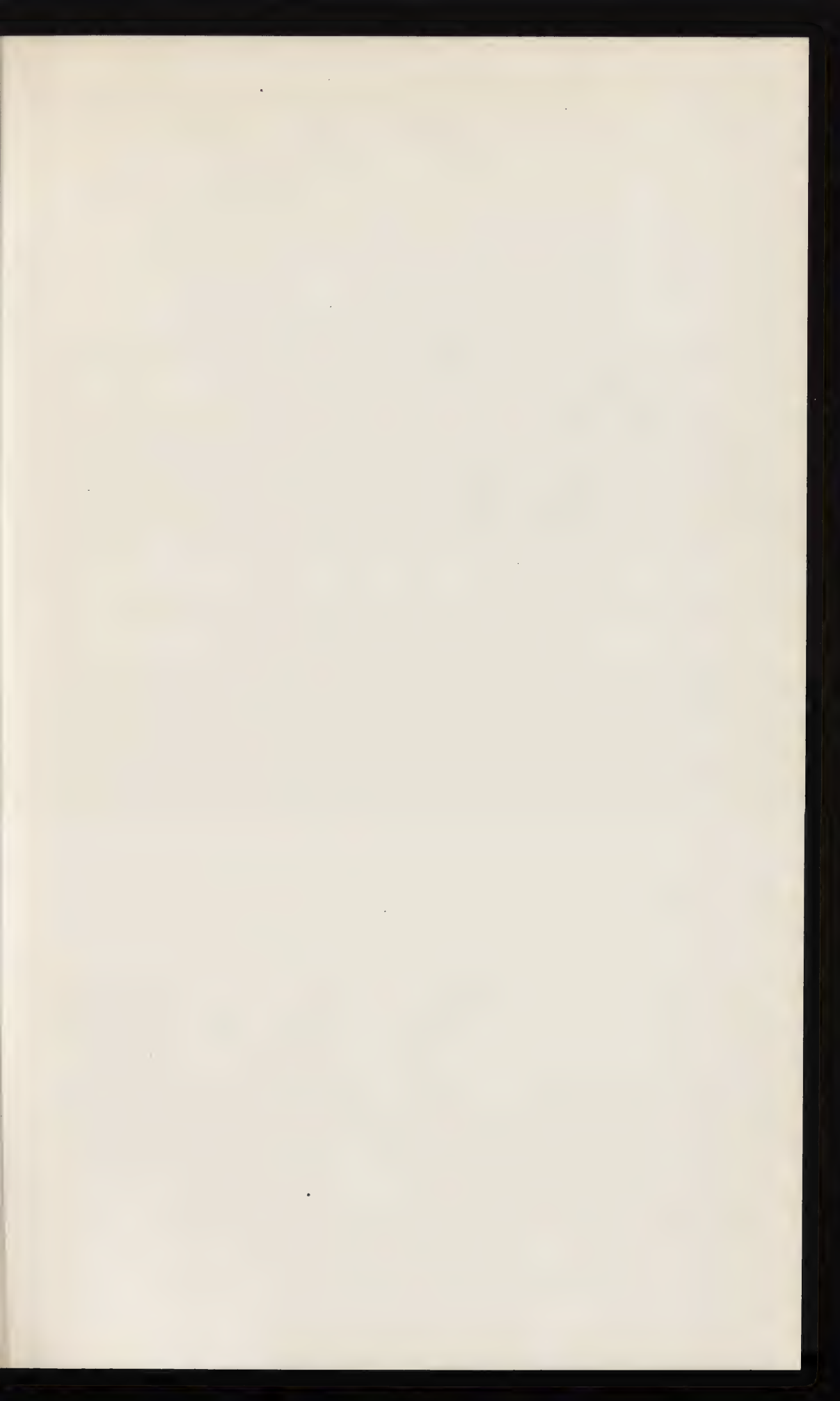
Dr. Aristides Mestre, of the University of Havana, has recently been named Titular Professor of Anthropology at the same University. He takes the place of Professor Montané, who retired on account of age.

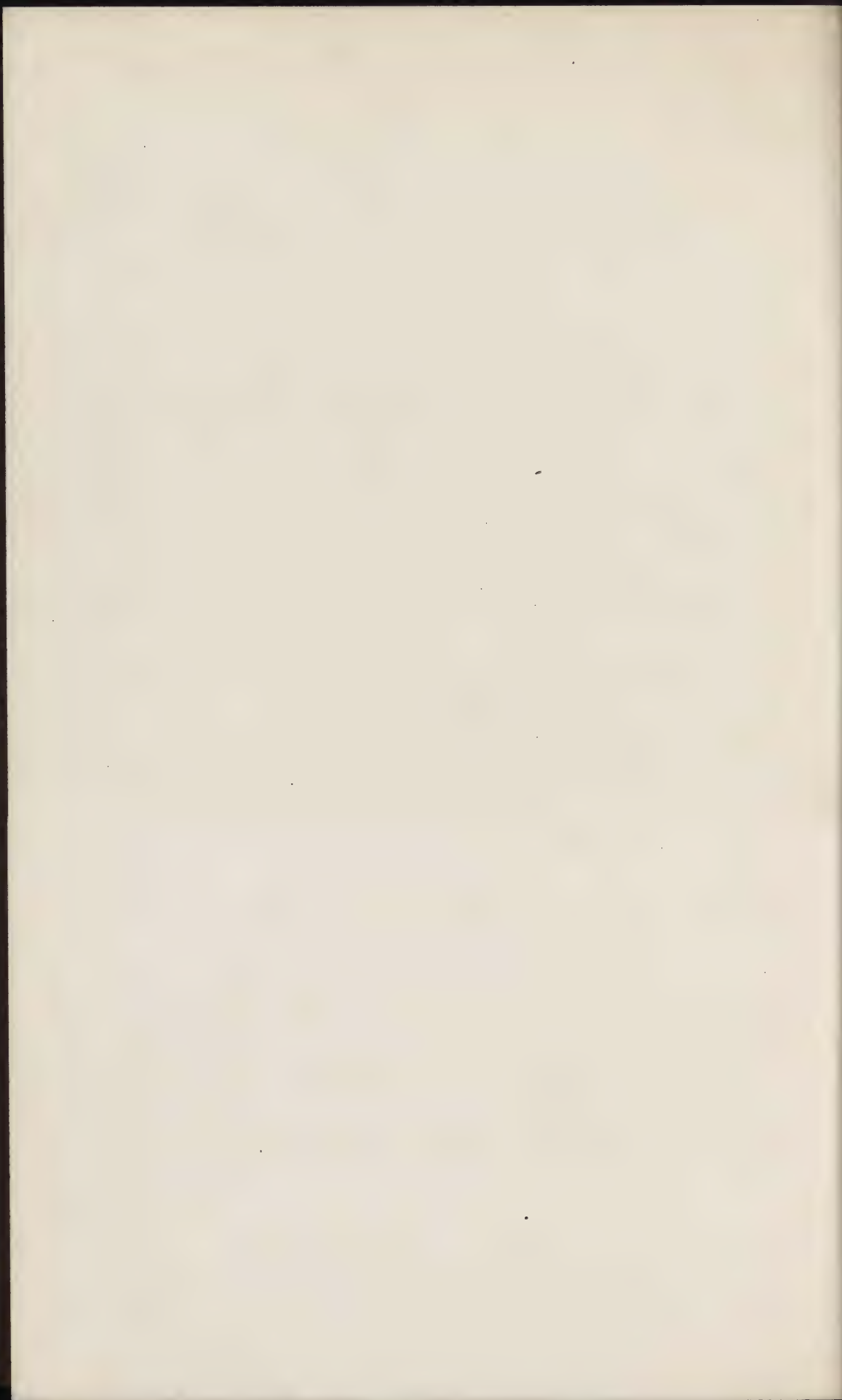
Dr. H. Stieve, M.D., PH.D., Prosektor of the Anatomical Institution of the University of Leipzig, Germany, has been charged with anthropological instruction which was formerly given by Dr. Emil Schmidt. Dr. Stieve will be grateful for reprints on the subject of Physical Anthropology.

The World Metric Standardization Council (San Francisco) appeals to all the Anthropologists of this country to further the use of the metric system, which professional workers in their line have used from the beginning, to all work of anthropometric nature in the United States. It also bespeaks the support of the Metric Standards Bill which has just been introduced in Congress by Hon. J. S. Frelinghuysen of New Jersey in the Senate, and by Hon. Fred A. Britten of Illinois in the House of Representatives. The measure provides for the gradual transition to the decimal metric system of weights and measures during a transition period of 10 years. It applies to merchandising, not manufacturing. Manufacturers may use any units in production, but commercial transactions are to be on the decimal basis, already used to such advantage in scientific work and in the coinage of the United States of America.









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## THE TYPES OF SCAPULÆ

A COMPARATIVE STUDY OF SOME CORRELATED CHARACTERS IN HUMAN SCAPULÆ

WILLIAM WASHINGTON GRAVES, M. D.

*St. Louis*

### I. SCAPULAR CLASSIFICATION

Finding in 1906 frequent variations in the contour of the vertebral border below the scapular spine in the living, and later finding the identical variations in fetal, child and adult scapulae in skeletal material, the writer was led to make a comparative study of several scapular characteristics and to publish the results in 1910 (1). This study demonstrated (1) that the character of the vertebral border below the scapular spine discloses wide variation not only in contour, but likewise in thickness and in other morphologic features; (2) that the character of the vertebral-border contour below the spine is correlated with other scapular peculiarities; and (3) that the character of the vertebral-border contour below the spine enables one to classify human scapulae into readily distinguishable types.

<sup>1</sup>GRAVES (W.W.), The Scaphoid Scapula: A Frequent Anomaly in Development of Hereditary, Clinical and Anatomical Significance. *Med. Record* (N. Y.), 1910, lxxviii., 861-873.

<sup>2</sup>GRAVES (W. W.), The Clinical Recognition of the Scaphoid Type of Scapula and Some of Its Correlations. *J. Am. M. Ass'n*, Chicago, 1910, LV., 12-17.

<sup>3</sup>GRAVES (W. W.), Some Remarks on the Scaphoid Scapula and Its Syndrome. *Trans. Nat'l Ass'n for the Study of Epilepsy*, June 16, 1911, VIII., 56.

<sup>4</sup>GRAVES (W. W.), The Age Incidence of the Scaphoid Type of Scapula: Its Bearing Upon Problems of Racial Morbidity. *Contrib. Med. & Biol. Research*, ded. to Sir William Osler, 1919, I, 525-532.

AMER. JOUR. PHYS. ANTHROP., VOL. IV, NO. II



Recent personal observations on scapulae of other Primates (orang, gorilla, chimpanzee et al.) and other mammals (armadillo, hedgehog, bat, otter et al.) have disclosed the presence of vertebral-border forms and variations similar to those noted in human scapulae. These observations led to the investigation of a larger human material than that formerly accessible and to making further comparison of the more distinct characters present in human scapulae. The purposes of this communication are: (1) To present the results of these investigations of human scapulae and of the characters disclosed by them; and (2) to offer the results of these investigations as a basis for comparison and classification of scapulae in man and in various mammalian species.

Older illustrated works on anatomy (Vesalius, Eustachius, Albinus, Monro, J. Browne, and others), anatomical drawings of the old Masters (Michael Angelo, Titian, Raphael, Da Vinci), and not a few of the later anatomical works, picture scapulae showing variations of the vertebral-border contour, but in no anatomical work up to the present time have these variations been described.

Variations of the vertebral-border contour in man and in several other primates were noted by Mivart<sup>1</sup> in 1867. Under the heading "Exceptional Forms," he states: "The vertebral margin is generally more or less convex, but sometimes in man, the gorilla and orang, *Ateles* and *Chrysothryx*, it presents a sigmoid curve. Sometimes it is nearly straight as in the *Indris*; sometimes it is very strongly convex as in the *Perodicticus*.

Dwight<sup>2</sup> in 1887 described scapular vertebral-border variations in man as follows: "The most common form of scapula presents a line slightly curved at the lower part and then straight as far as the root of the spine from which point it inclines slightly forward till it ends at the upper angle. The forward inclination of the upper part, though varying in degree, in so far as I know is constant, but the rest of the line varies much. Sometimes it is almost straight; sometimes the whole border of the bone is convex; sometimes the border below the spine is concave."

Hrdlička who since 1899 studied independently the types of long

<sup>1</sup>MIVART (ST. G.), On the Appendicular Skeleton of the Primates. *Philos. Trans.*, Lond., 1867, clvii., 299-429.

<sup>2</sup>DWIGHT (THOMAS), 1887, The Range of Variation of the Human Shoulder Blade. *Am. Nat.*, Vol. 21, p. 627.

and other bones, describes<sup>1</sup> and gives comparative data on three main and two secondary forms of scapulae as follows: "The scapula as a whole may be more or less neatly triangular or wedge-shaped, which form will be designated as type 1. Again, it may be more acutely wedge shaped, with both its axillary and vertebral border markedly concave, a type which the author classes as 3. It may be quadrilateral, type 4, with the axillary border augmented by a shorter but well-marked inferior border, due to a development of a process or angle by the influence of the *teres major* muscle. It may be pentagonal, when the preceding type is augmented by a distinct angle in the vertebral border at or above the spine, which divides it into two well marked borders—type 5. Finally, we may have a shape resembling that in many lower mammals and characterized by marked convexity of the vertebral border, which will be referred to as type 6."

Prior to the classification of human scapulae proposed by the writer in 1910 there appears to be no previous record of a scapular classification either of man or of other mammals. Prior to my observations on the living in 1906 no one had, so far as I know, attached particular importance to scapular vertebral border variations. Moreover, no one had called attention to the hereditary nature, to any of the correlations or to the age incidence of scapular types (1), (2), (3), (4).

The present classification of human scapulae is an amplification of that classification proposed by me in 1910. It is applicable to living as well as to skeletal material. The classification is based primarily upon the relation of a straight line to the character of the greater portion of the vertebral border below the scapular spine, beginning approximately at the point of mergence of the scapular spine with the vertebral border and ending approximately at the inferior angle or at a variable point below the level of the process for the *Teres major* muscle.

If one will examine a sufficiently large number of human scapulae and will note the character of the vertebral border in each within the limits just defined, he will have no difficulty in recognizing three distinct types as follows:

<sup>1</sup>HRDLÍČKA (A), Physical Anthropology of the Lenape or Delawares, and of the Eastern Indians in General. *Bull. 62, Bur. Am. Ethnol.*, 1916, 75-76. See also his "Anthropometry," 8°, Wistar Inst., 1920, 131.

The "convex": The most common type (A)

Scapulæ, whose vertebral borders throughout the greater portion below the scapular spine are regularly or irregularly, slightly (near-straight), moderately or markedly convex, and here called "convex" or "Cv. 1," "Cv. 2" and "Cv. 3" type. (Pl. II, A.)

The "straight": A less common type (B)

Scapulæ, whose vertebral borders throughout the greater portion below the scapular spine are "straight" or nearly so (not convex) tending rather to concavity than to convexity (the rule) and here called the "straight", or "St." type. (Pl. II, B.)

The "concave": The least common type (C)

Scapulæ, whose vertebral borders throughout the greater portion below the scapular spine are uniformly or irregularly, slightly, moderately or markedly concave and are here called the "concave" or "Cc. 1," "Cc. 2" and "Cc. 3" type. (Pl. II, C.)

Scapulae of Anthropoids, without exception, will fall into one or another of these classes.

Scapulae of Hominidae disclosing either "straight" or "concave" vertebral borders throughout the greater portion below the scapular spine, when carefully studied, disclose a number of other characters, which serve further to differentiate them ("straight" and "concave") from scapulae having more or less "convex" vertebral borders. In my first study (1) I pointed out six correlated characters which serve to differentiate both the "straight" and "concave" types from the "convex." These correlated features or similarities in the "straight" and "concave" types led me to give these two types ("straight" and "concave") a common name, and I designated them the "scaphoid type of scapula." Further personal studies of scapulae have not only verified my earlier observations, but they have resulted in finding additional characters which still further differentiate both the "straight" and "concave" from the "convex" type. The more distinct characters thus far noted in the "convex," "straight" and "concave" scapular types are tabulated below.

..

Before turning to the study of the more distinctive characters in scapular types, some explanation should be made concerning the measurements made for indices and angles, and definitions must be given of certain descriptive terms herein employed.



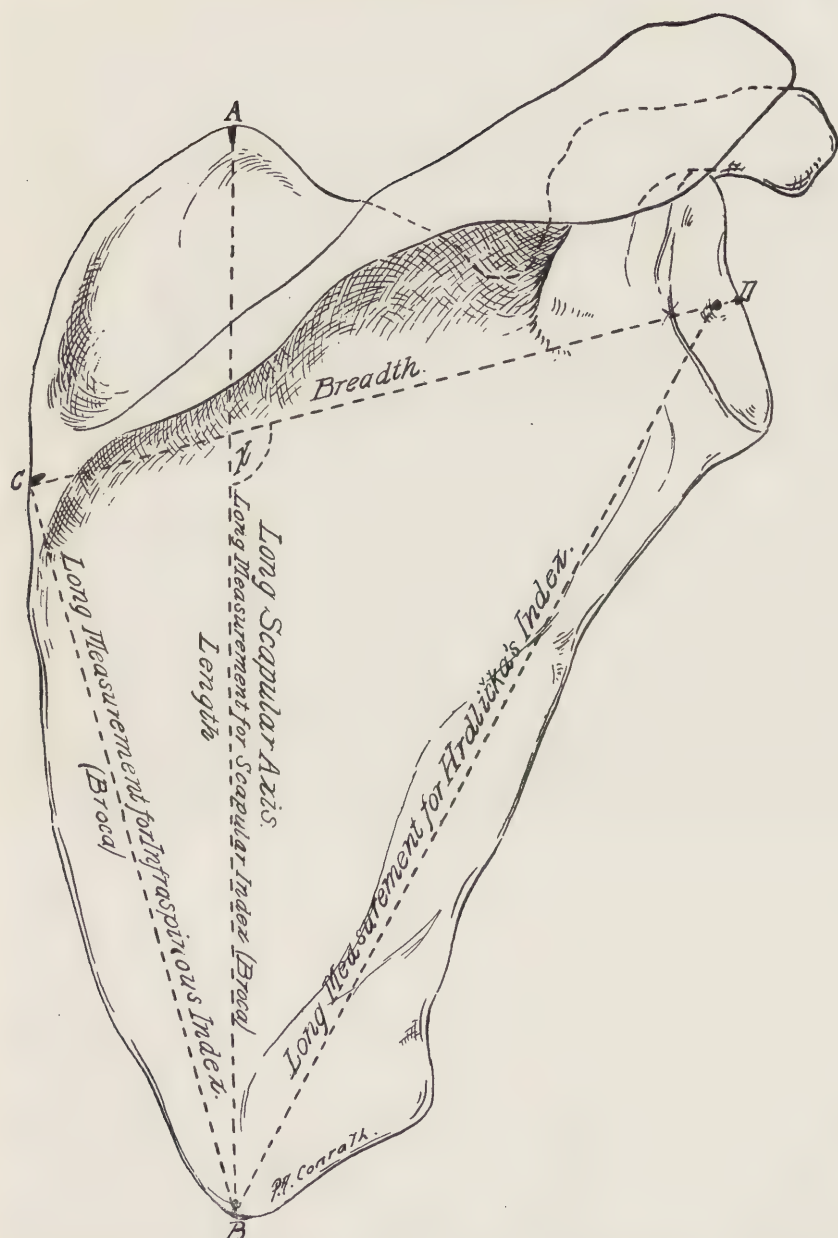


PLATE I. A convex type of scapula showing landmarks used in measurements recorded in this paper. (Drawing by P. A. Conrath, St. Louis.)

The method of taking measurements for indices in this study was recommended by Dr. A. Hrdlička, and is as follows: With a sharp-pointed pencil points are marked at superior angle A, inferior angle B, vertebral border point C and glenoid point D, Pl. I. The superior and inferior angles A and B are usually easily identified on a mature complete scapula, but points C and D require a few words of explanation. Point C is located by so holding a scapula that the midline of the *first* part of the scapular spine may be prolonged to the vertebral border. This manner of locating point C is more accurate than the method suggested by Martin,<sup>1</sup> which is to divide equally the space bounded by the mergence of the lips of the scapular spine with the vertebral border. The mergence of these lips is often variable and indefinite; hence Martin's method of locating point C must also be indefinite and variable, and, therefore, some source of error.

The *glenoid point D* was demonstrated to me by Dr. Hrdlička. In the glenoid of a mature scapula one will note in its approximate centre a slight depression or elevation (crater or slit-like form or a papilla). This is a constant feature on all mature scapulae and the approximate center of this depression or elevation is the *glenoid point D*. In primates generally this feature is present although usually less defined than in man. The use of this point in scapular measurements must eliminate definite sources of error. Heretofore measurements of scapulae were taken by most investigators from the middle of the dorsal or outer part of the border of the glenoid. A study of scapulae will show however, that this margin in some bones is sharp; in others rounded and in still others defective; hence a measurement taken from the vertebral border point C to such a variable point cannot but be a source of some error. This error is readily eliminated if the measurement of the *breadth* be taken with spreading calipers between points C and D. The glenoid point also serves as a landmark for another important measurement; i. e. the length from this point D to the inferior angle B. Martin recommends a measurement from the inferior angle to the inferior margin of the glenoid—the long measurement for the “axillary marginal index.” The same objection to the use of the variable glenoid margin as a fixed point for a measurement noted above in reference to the breadth holds true for the measurement for the axillary marginal index: whereas if the two fixed points D and B are used for

<sup>1</sup>MARTIN (R.), *Lehrbuch der Anthropologie*, Jena, 1914.

measurement, a possible source of error is eliminated. The measurement D-B is the long measurement for an index here called the *glenoid point—inferior angle index* (Hrdlička). In this study measurements for three scapular indices were taken, which for practical purposes seem to meet all requirements and the formulas are as follows:

- I. Scapular index<sup>1</sup>  

$$\frac{\text{The breadth C-DX100}}{\text{The length A-B}}$$
- II. Infrapinuous index<sup>1</sup>  

$$\frac{\text{The breadth C-DX100}}{\text{The infrapinuous length C-B}}$$
- III. Glenoid point—inferior angle index (Hrdlička)  

$$\frac{\text{The breadth C-DX100}}{\text{Glenoid point—inferior angle length D-B}}$$

It will be noted that the measurement of the *breadth C-D* is the same for each index. With but few exceptions (when bones were broken) measurements for the three scapular indices were taken on each bone tabulated below and in Part II.

The writer's observations have shown that the spines in scapulae whose vertebral borders are either "concave" or "straight" more nearly form a right angle with the long scapular axis than do the spines in the "convex" types. These observations made it desirable to devise a method for measuring such angles in scapular types. In primates below man the scapular spine quite generally forms a wide (open) angle with the long scapular axis (Pl. IV Figs. 1, 2, 3): whereas in man this angle is nearer to a right angle and in some instances is even less than a right angle (Pl. III Figs. 4, 5, 6). The spine of the human scapula beginning at the variable vertebral border rises in its course to a variable height from the body of the bone and terminates in the widely varying acromion process. The dorsal surface of the spine also varies in width and shape along its course. To secure land-marks, therefore, amid such wide variation seemed to be an insurmountable problem. But, while it is true that the spine shows wide variation in the several parts just mentioned, this is not true of the attachment (root) of the spine to the body of the bone. If one holds a scapula with the glenoid fossa facing the eye, it will be noted that an imaginary straight line beginning at the vertebral border point C passes very

<sup>1</sup>BROCA (P), Sur les indices de largeur de l'Omoplate chez l'Homme les singes et dans la série des Mammifères. *Bull. Soc. d'Anthrop.* Paris, 3me, ér. 7 I, 67.



accurately through the axis of the attachment of the spine to the body of the bone, and that a prolongation of this line passes through, or just above the glenoid point D. I have therefore used this point as the terminus of an imaginary straight line drawn from C Pl. I. The line A-B corresponding to the long scapular axis is used as a base line and the line C-D for the second line in angle measurements. The method of posturing a scapula for finding the angle formed by the intersection of the line D-C with A-B is as follows:

Posture a scapula, dorsal surface up, so that the long scapular axis A-B is superimposed upon a straight line previously ruled on a sheet of blank paper; then drop verticals opposite points C and D, marking the points; unite the points thus marked and a measurable angle X results (Pl. I.) \*

One should choose only those scapulae whose land-marks are intact and whose superior and inferior angle regions are well defined—neither squared, broadened nor unduly rounded (unusual variations). The method used in this study is subject to error in posturing a bone, in dropping verticals and in the nature of the superior and inferior angle regions. Recognizing the sources of error just mentioned the method gives graphic results, is easy of application, rapid, fairly accurate and when carefully applied to properly selected scapulae, gives good comparable values. For this part of the study 20 fairly typical scapulae from each class were measured and the results are tabulated below.

The descriptive terms referred to above have to do with "vertebral border buds" and "vertebral border remnants." A "vertebral border bud"\* is here defined as, a process (varying in location, size and number) springing up from the margin of the thinned vertebral border above and below it (Pl. II. A3, B3, 4, 5 and C2). A "vertebral border remnant" is defined as a portion of the vertebral border system (lips and intermediary surface) morphologically more or less

\*Dr. Hrdlička suggested a method to me for indicating the inclination of the scapular spine, which may serve as a control to that proposed in the text and is as follows: measure the length of lines D-B, C-B and D-C, project on paper, and measure angle at D. The value of this method lies in enabling one to express comparable values in figures irrespective of the state of nature of the superior angle region. But the base of the scapular spine, the inferior angle and the glenoid point must, of course, be intact.

perfect with the border straight or concave above or below it (Pl. II, C3, 5).\*

The characters disclosed by human scapulae, whose vertebral borders are convex, straight or concave throughout the greater portion below the scapular spine and within limits before mentioned may be conveniently given in a tabular form:

CHARACTERIZATION OF SCAPULAE ACCORDING TO TYPE

CHARACTER	CONVEX	STRAIGHT	CONCAVE
I. The vertebral border in relation to a straight line	Uniformly or irregularly; slightly (near straight), moderately or markedly convex (Cv. 1, Cv. 2 and Cv. 3). (Pls. 11, 111, A.)	Straight or nearly so, never convex. (Pls. II, III, B) (St.)	Slightly, moderately or markedly concave (Cc. 1, Cc. 2 and Cc. 3). (Pls. II, III, C)
II. Thickness of vertebral border	<i>Thickened</i> ; lips and intermediary surface usually well marked. (Pl. III, Fig. 1)	<i>Thinned</i> ; lips and intermediary surface occasionally well developed, but in general rather rudimentary. (Pl. III, Fig. 2)	<i>Thinner</i> than in straight, lips and intermediary surface are seldom prominent; rudiments occasionally in Cc. 1; seldom in Cc. 2 or Cc. 3, and in these ventral and dorsal surfaces often converge to sharp edge. The greater the concavity, the less marked the lips and intermediary surface of the vertebral border. (Pl. III, Fig. 3)
III. Vertebral border "buds"	Seldom found in moderately and markedly convex, often in slightly convex types. (Pl. II, A 3)	Abound in this type varying in size, number and location. (Pl. II, B 3, 4, 5)	Frequently found in Cc. 1; seldom in Cc. 2 and in Cc. 3, and in these usually single and often located somewhat above inferior angle. (Pl. II, C 1)

\*"Vertebral-border buds" occur in all types, but are most common in the "slightly convex", the "straight" and slightly "concave" types. They are present not only in mature bones but likewise in fetal, infant and child scapulae—in periods when the vertebral border is still wholly cartilaginous. The variation in location, size and number of "vertebral-border buds" suggest that their origin is independent of the influence of vertebral-border muscles. The lips and intermediary surface of the vertebral border are probably adaptations to muscle function, since these features are seldom if ever missing in the "convex" types. Moreover, these markings are present in well developed "buds." They, therefore, appear to be intimate parts of the form of scapula peculiar to the individual—merely one among many morphologic expressions of his "endowment." The same assumptions hold true for "vertebral-border remnants."

CHARACTER	CONVEX	STRAIGHT	CONCAVE
IV. Vertebral border "remnants"	Seldom found present.	Occasionally found.	Abound in this. Most often found in Cc. 1 and Cc. 2; usually located just below the spine, or above inferior angle extending downward or upward variable distances. (Pl. II, C 5 & 3)
V. Average indices in modern mixed white and black dissecting-room material, U. S. N. M. and Wistar Institute	Scapular index in 426 bones average 65.1; Infraspinous index in 445 bones average 85.5; Glenoid point-inferior angle index (Hrdlička) in 445 bones average 72.3.	Scapular index in 205 bones average 63.0; Infraspinous index in 215 bones average 85.2; Glenoid point-inferior angle index in 215 bones average 70.2.	Scapular index in 182 bones average 62.5; Infraspinous index in 186 bones average 83.0; Glenoid point-inferior angle index in 186 bones average 69.8.
VI. Long scapular axis—spinal angle in 20 scapulae	Angle, range 90 to 100; average 95.9. (Pl. III, Fig. 4)	Angle range 87 to 97; average 93.4. (Pl. III, Fig. 5)	Angle range 85 to 98; average 92.1. (Pl. III, Fig. 6)
VII. Relation of vertebral border below spine to a straight edge:	May parallel straight edge in part, but deviates downward and outward (Pl. V)	Parallels or nearly parallels straight edge—and does not deviate. (Pl. V)	Relation to straight edge above and below nearly the same as in the "straight," but concave more or less in the rest of the border. (Pl. V)
VIII. Relation of Teres Major process to axillary border:	Usually forms a definite angle with axillary border. (Pls. II, III A)	Less frequently forms a definite angle with axillary border. (Pls. II, III B)	Seldom forms a definite angle with axillary border and often merges with it in a graceful curve. (Pls. II, III C)
IX. Relation of long axis of glenoid to long scapular axis when scapula is postured with superior angle uppermost and long scapular axis vertical:	The line E-F usually shows marked divergence from the line A-B and seldom parallels it. (Pl. III A)	The line E-F usually shows lessened divergence from line A-B. (Pl. III B)	The line E-F usually shows still less divergence from line A-B; in some paralleling it, and in rare instances converging toward it. (Pl. III C)



CHARACTER	CONVEX	STRAIGHT	CONCAVE
X. Inferior angle region:	As a rule, broadened, squared or rounded; seldom pointed. (Pls. II, III A)	As a rule, narrowed and pointed; occasionally rounded; seldom squared. (Pls. II, III B)	Similar as in the straight. (Pls. II, III C)
XI. Margin and depth of glenoid:	Usually has distinct, rather uniform margin with good depth of concavity.	Margin of glenoid is often rudimentary in part and the concavity is often shallow.	Margin of glenoid is often rudimentary in part and the concavity more often shallow than in "straight."
XII. Transmitted light:	Shows increased density as the body of the bone approaches vertebral border becoming usually definitely and uniformly opaque near-to and at the lips.	Lessened density, and as the body of the bone approaches the vertebral border opalescent areas and areas of density often commingle and extend into the thinned vertebral border and rudimentary lips.	Cc. 1, Cc. 2 and Cc. 3 types show diminishing density as body nears vertebral border, itself often being opalescent and in the Cc. 2 and Cc. 3 types the border is often as thin as the body of the bone.
XIII. Paired scapulæ:	Moderately and markedly convex types seldom show marked variations of vertebral border or otherwise when compared one with the other.	Often show marked variation of vertebral border, in indices, vertebral border "buds," angles and markings.	Similar as in the straight type.
XIV. The entire scapula:	As a rule shows definite surface markings for muscles; is heavier when compared with straight and concave types showing approximately similar long scapular axis measurements; is a bone which may be called <i>strong</i> .	As a rule shows somewhat less definite surface markings for muscles; is mostly lighter when compared with convex type, and is a bone in general weaker than that of the convex type.	As a rule, shows less definite surface markings for muscles when compared with the "straight" and especially with the "convex" types and the Cc. 1, Cc. 2 and Cc. 3 in order named are, as a rule, <i>weak, weaker, weakest</i> .

Through the courtesy of Dr. M. B. Titterington I have been able to study with the aid of the X-ray twenty scapulae of each type on the living, and the results are as follows: (1) No structural differences were found in "bud," "remnant," "Teres major process" and other markings in the *three* types; (2) The "convex," as a whole, shows relatively more cancellous tissue, and is relatively of greater density than the "straight" and "concave" types.

Among the characters not submitted to comparison in the foregoing study are: the vertebral border above the spine; the superior angle; the superior border; the suprascapular notch; the coracoid; the first and second divisions of the spine; the acromion; the clavicular facet; the infraglenoid process; the inferior border; the cristae; and the axillary border. Each of these characters, like others herein tabulated, show wide variation, and will receive consideration in further studies.

#### COMMENT

Two essential points applicable to the present scapular classification must here be emphasized: (1) That however slight the degree of convexity of the greater portion of the vertebral-border below the scapular spine may be, such a bone was classified a "convex" type; and (2) that in the "straight" type the greater portion of the vertebral-border below the scapular spine is seldom perfectly straight but tends frequently to concavity.

A comparison of the chief characters noted in human scapulae reveals a few characters common to the three types defined and differentiated in this study. Moreover, one would be warranted in saying that almost any character thus far submitted to comparison is found in scapulae of any type save the one peculiar to each—the character of the greater portion of the vertebral-border contour below the scapular spine. But, it is the fundamental nature of this part of the bone ("convex," "straight," "concave") which primarily affords a definite basis for classification and which enables us to differentiate one type from another in skeletal and living material. A secondary basis for classification is found in the additional characters peculiar to each scapular type.

While all scapular types reveal a few characters in common, it is in the "straight" and "concave" types that the greater number of similar characters is found. A series of anatomical and architectural characteristics common to the "straight" and "concave" types are shown in the foregoing tabulation. Moreover, the differences between the "straight" and "convex" types are shown to be greater in number and degree than are the differences between the "straight" and "concave" types. These facts lead to the reasonable conclusions that the "straight," although not strictly identical with, is nevertheless closely related to, the "concave" type; and (2) that both the "straight" and "concave" types are variants when compared with the "convex" types

of scapulae. The tabulations in Part II will show that the "straight" and "concave" types make up, respectively, relatively large percentages of the groups representing modern and ancient man. Notwithstanding this fact, we shall find in the tabulations that the "convex" type is still the predominating type in dissecting-room material with an average age of fifty years, thus far classified in this country.\*

## II.

### FURTHER OBSERVATIONS ON SCAPULAR CLASSIFICATION WITH TABULATIONS OF CLASSIFICATION AND MEASUREMENTS OF ANCIENT AND MODERN GROUPS.

The classification in Part I was based originally on a study of 198 mature scapulae from mixed white and negro stock found in the Department of Anatomy of the St. Louis University and Washington University Schools of Medicine. To this number were added 150 bones presumably from whites, which through the courtesy of Prof. Waldeyer I was able to classify in the Department of Anatomy in the University of Berlin in 1910, thus making the total at that time 348 bones. The result of the classification of the 348 scapulae from mixed stock in St. Louis and Berlin expressed in percentage was:

Convex Type	Straight type	Concave type
61%	26%	13%

In 1919 through the courtesy of Dr. A. Hrdlička, and of Dr. M. F. Greenman, Director of the Wistar Institute of Anatomy and Biology, I had the opportunity of classifying and measuring larger collections of modern scapulae. The scapulae studied in the Wistar Institute were also from mixed white and from American negro stock and numbered 602 mature bones. Those studied in the U. S. National Museum

\*It seemed important to learn, if possible, the average age of dissecting-room material, but it was not until the summer of 1919 through the courtesy of Dr. Hrdlička, that I was able to get accurate information bearing upon this question. The data in his possession had been acquired from 1009 bodies dissected by students of Prof. Geo. S. Huntington in the Department of Anatomy of Columbia University. The range in years was from 15 to 96, the greater number being over 35, and yielded an average age of 46.8 years. Through the courtesy of Dr. D. M. Shoemaker, Local Secretary of the Missouri Anatomical Board, I have been able to tabulate the figures in reference to average age in dissecting-room material, covering a recent 3 year period, distributed to the medical schools of Missouri. In approximately 750 bodies, the average age was 54.6 years, so that it may be stated with confidence that the average age of combined dissecting-room material thus far tabulated in Missouri, New York City and Philadelphia is approximately 50 years.



were mainly from the Huntington collection of modern whites and numbered 269 bones. The collections studied in St. Louis, Berlin, Philadelphia and Washington have this in common, that all the bones were derived from dissecting-room material. The combined number of bones on which the proposed classification is based is 1219. The classification and percentages of this number are as follows:

	Bones	Percentage
Convex	663	54.3
Straight	320	27.0
Concave	236	18.7

Recent studies, made possible through the courtesy of Dr. Hrdlička, based upon scapulae of ancient races in the U. S. National Museum, show that the same vertebral border variations are present in the pre-white Pueblo, pre-Columbian Peruvian and Illinois River Indians, and in Egyptian (XII to XXV Dynasty) scapulae, as are found in the scapulae of modern Indian, Negro, Chinese, white and in all other modern races of man represented in this great Institution. The same is true of a number of scapulae of pre-dynastic Egyptians; of the 10th century Icelanders (probably Europeans); Canary Islanders (Guanches); and pre-Columbian Arizona Indians, recently studied by me through the courtesy of Dr. E. A. Hooton (Peabody Museum); also of a number of Esquimo, Northwest Coast, Arizona and New Mexico Indian scapulae which I examined through the courtesy of Dr. Clark Wissler, at the American Museum of Natural History. Personal observations of groups of living individuals representing various races and social levels in this country have shown the presence of identical vertebral-border variations noted in the skeletal scapulae of all ancient and modern races thus far investigated. These findings indicate that all races of man at all times have shown similar scapular variations. The presence of similar vertebral-border variations in other primates and other mammals lends further support to this inference.

Measurements of Egyptian, pre-Columbian Peruvian, pre-white Pueblo and modern dissecting-room groups are given in the accompanying table (p. 125).

The bones tabulated in groups A, B, C and D in reference to classification and measurements were examined in the U. S. National Museum, and those in Group E in the Wistar Institute of Anatomy and Biology. All the bones in each group were in good state of preserva-

## CLASSIFICATION AND MEASUREMENTS OF ANCIENT AND MODERN GROUPS OF SCAPULAE

Group	Type	No. of Spec.	Per-cent	Scapular Index BX x 100			Infraspinous Index BX x 100			Hrdlicka Index BX x 100		
				L			Infrasp. L.			Gl. Pt. Infer. Angle L.		
				Aver.	Min.	Max.	Aver.	Min.	Max.	Aver.	Min.	Max.
A Egyptian (XII to XXV Dynasty)	Convex...	20	44.4	(16) 72.5	59.5	87.7	(20) 98.4	81.5	125.0	(20) 73.2	65.4	83.3
	Straight...	13	28.8	(7) 67.2	67.0	70.1	(93) 89.9	87.3	92.1	(13) 73.5	68.7	72.1
	Concave...	12	26.8	(8) 65.3	62.1	68.0	(12) 82.5	80.9	90.9	(12) 71.2	68.0	72.4
B Peruvian Indians Pre-Columbian	Convex...	32	66.6	(19) 65.7	62.1	70.3	(32) 85.5	81.3	88.1	(32) 73.1	72.7	72.5
	Straight...	11	22.5	(10) 63.0	58.3	69.3	(11) 81.1	75.0	92.9	(11) 72.1	67.7	76.4
	Concave...	5	10.9	(5) 65.5	60.2	69.2	(5) 85.0	92.0	90.0	(5) 71.7	71.0	75.0
C Pueblo Indians Pre-White	Convex...	77	69.3	(42) 68.7	61.0	78.4	(76) 89.9	89.1	91.0	(77) 75.6	71.0	79.7
	Straight...	22	19.8	(13) 67.1	61.7	70.8	(22) 87.2	76.9	92.0	(22) 73.0	74.6	80.7
	Concave...	12	10.9	(7) 65.7	59.5	68.2	(12) 84.5	72.3	86.7	(12) 71.4	64.9	73.0
D Modern White Dissecting Room	Convex...	141	52.4	(130) 65.0	56.0	74.0	(141) 87.5	71.8	95.0	(141) 71.1	67.1	81.4
	Straight...	59	22.3	(58) 62.2	54.5	68.7	(59) 82.8	61.7	100.0	(59) 69.5	64.0	73.3
	Concave...	69	25.3	(68) 62.8	53.4	72.3	(69) 82.2	68.8	100.0	(69) 69.5	61.3	76.4
E Modern White and Black Dissecting Room	Convex...	317	52.6	(297) 64.7	54.3	77.7	(304) 88.4	69.6	103.7	(304) 72.0	62.6	80.0
	Straight...	166	27.5	(146) 63.3	53.1	70.0	(155) 86.2	70.4	95.4	(155) 70.6	65.0	73.9
	Concave...	119	19.9	(113) 62.8	52.3	66.9	(115) 83.4	66.4	96.6	(115) 69.7	63.5	68.5

tion with reference to points for measurements, and it was thus possible with few exceptions to secure measurements for the three indices on all bones in each group. The number of bones in each class with the percentages, the average indices of each class and the range in variation of indices in each class are shown in the table. The number of bones in the Egyptian, Peruvian and Pueblo groups (A, B and C) is in each too small to be definitely comparable with the modern groups (D and E). The classification and measurements in the modern groups (D. and E) show striking similarities. Further comparisons should be withheld until larger collections of ancient scapulae shall have been classified and measured.

FURTHER OBSERVATIONS ON SCAPULAR CLASSIFICATION  
AN INTERMEDIATE OR TRANSITIONAL TYPE

Any natural classification leading to the recognition of types must be based primarily upon some constant feature. The feature upon which this classification of human scapulae is primarily based here is, as already stated, the greater portion of the vertebral border contour below the scapular spine in its relation to a straight line. This contour ranges from convex to straight and concave, giving us three corresponding main scapular types, which differ in various additional particulars. The relative frequency of these types has been shown in the table. But there are no sharp lines of division. Taking for instance a series of scapulae of the convex type, some of whose vertebral borders may be classified as moderately and others as slightly "convex," and contrasting these with a number of bones whose vertebral borders are classifiable as "straight" and others as "concave," one becomes aware of the fact that the nearer the vertebral border of a "convex" type approaches a straight line, the more closely such a bone resembles, in all respects, the features common to the "straight" and "concave" types. The studies of the combined Wistar Institute and Huntington (U. S. N. M.) collections show that the slightly "convex" (near-straight) type makes up approximately 6%, the moderately "convex" 85% and the markedly "convex" 9% of the "convex" types in this mixed stock dissecting room material; and seem to justify our regarding the slightly "convex" (near-straight) as an intermediate or transitional type between the moderately "convex" on the one hand and the "straight" and concave types on the other.

DIFFICULTIES IN CLASSIFICATION

Occasionally a difficulty is met with in differentiating between a slightly convex (near-straight) and a straight type of scapula in skeletal material, and this differentiation is more often difficult in the living. Even in the living however, except in obese or unusually well muscled individuals, the differentiation may, in most instances, properly be made. I have controlled such observation repeatedly with the aid of the x-ray.

A rather frequent vertebral border variation met with in "convex" types, but one which ordinarily leads to no confusion in classification, is the presence of a single concavity (1.0 to 2.5cm. long) occupying the



lower portion of the vertebral border just above the inferior angle. A most unusual vertebral border variation, most frequently found in the slightly "convex" (near-straight) types and which may at times lead to some confusion, is the presence of more or less concave upper and lower portions separated by a more or less convex middle portion. A rather common variation of the vertebral border usually found in moderately and markedly "convex" types, is a small concavity varying in length from 2.0 to 4.0 cm. at the base of the scapular spine (A1. Pl. II, Part 1); but in such a bone the greater portion of the vertebral border below the scapular spine is "convex," and by definition is therefore classified "convex." It is only when the concavity is greater, occupying one-third or more of the border—a very unusual variation (A5, Pl. II). that any confusion should exist, and classification would seem impossible only when for instance, just one-half of the border is "concave" and the other one-half "convex," a form of scapula rarely found in the approximately 3500 scapulae thus far examined.

On the whole, if it be remembered that the classification is based primarily upon the character of the greater portion of the vertebral border contour below the scapular spine in its relation to a straight line, there will seldom be found a human scapula either in skeletal or living material that cannot be classified "convex," "straight" or "concave."

#### SUMMARY

(1) The human scapula is a bone displaying many interesting characters.

(2) The nature of the greater portion of the vertebral-border contour below the scapular spine enables one to classify human scapulae into "convex," "straight" and "concave" types.

(3) A comparative study of other features peculiar to the "convex," "straight" and "concave" types, shows that the "straight" and "concave" have many characters in common. This is why the writer has named both the "straight" and "concave" the "scaphoid" type of scapula.

(4) The "straight" and "concave" types each makes up a relatively large percentage in the ancient and modern groups of scapulae thus far classified. In modern dissecting-room material with an average age of fifty years, in this country, the "straight" and "concave" types make up nearly 50% of the total; while in all ancient groups

thus far studied, excepting the Egyptian, the "convex" is definitely the predominating type.

(5) The "straight" and "concave" types are variants when compared with the "convex" type.

(6) The presence of "convex," "straight" and "concave" scapular types in all modern and ancient racial groups thus far investigated leads to the reasonable inference that the identical scapular types were primeval with man.

#### AFTER-WORD

Prior to the writer's observations in 1906, the human scapula had received little consideration as an accessible morphologic feature in the living. Since then he became convinced that it may well serve as a basis for correlation in studies of the total make-up of individuals. The human scapula is truly a bone of many characters, which fact alone suggests that it may be one of many correlations.

It is the writer's conviction that scapular types may become useful morphologic features as bases for correlation in studies of human resemblances, differences, variations and adaptations. This conviction is strengthened by the facts that, 1, scapular types are in most instances heritable from generation to generation; and 2, that each scapular type discloses an age incidence, the "convex" increasing while the "straight," like the "concave," decreases in frequency with each succeeding age period from childhood to old-age.

What factors, other than heredity, may be responsible for scapular types; whether all races of man from the beginning possessed the identical types of scapulae found in all ancient and modern races thus far investigated; and whatever the correlations of scapular types in modern man may be, are problems for further investigation.

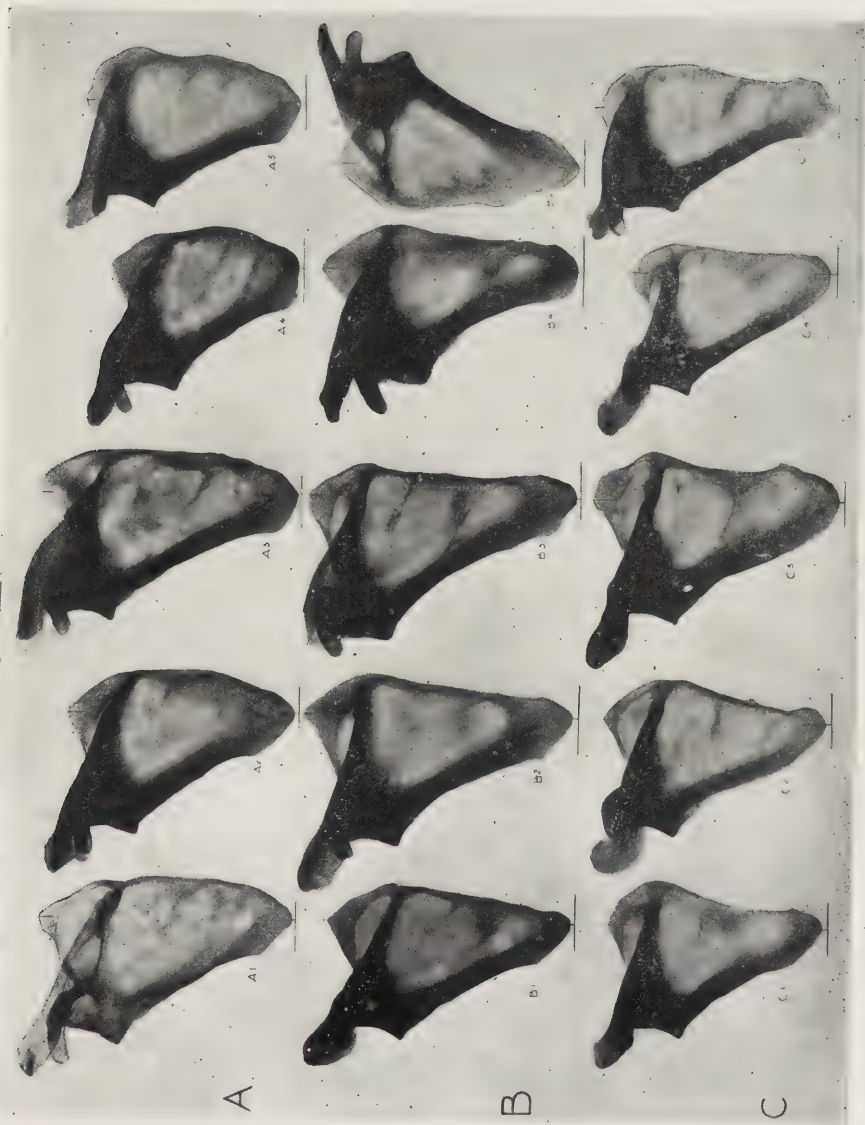


PLATE II. X-ray illustrations: A "convex," B "straight," C "concave" types. B 1, 3, 4, 5, show "vertebral border buds" varying in number, size and location. C 3 (above inferior angle) and C 5 (below the spine) show each a vertebral border "remnant."



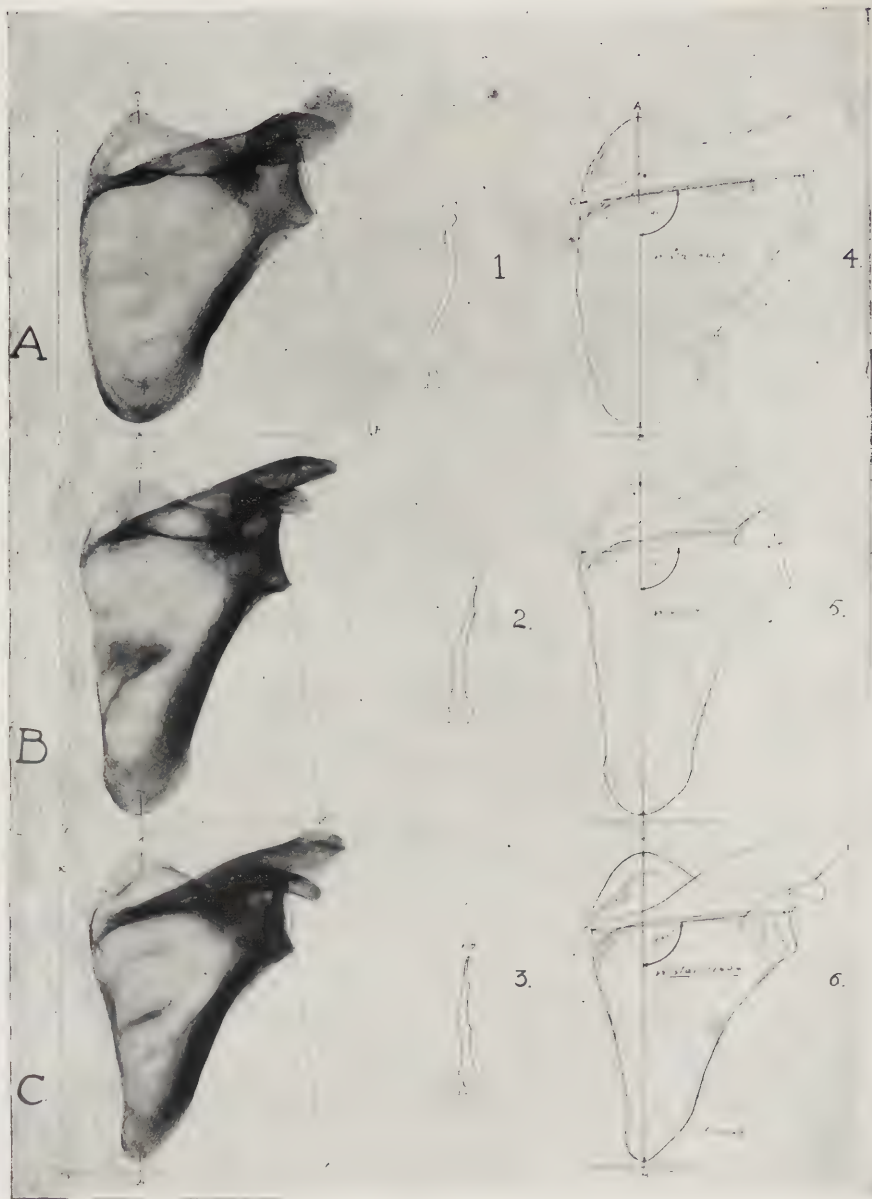


PLATE III. X-ray illustrations and drawings of same scapulæ 4, 5, 6, with schematic cross-sections 1, 2, 3, of "convex," "straight" and "concave" types. Each scapula is posed with long scapular axis vertical A-B to show the relation of the vertebral border to vertical line X-Y and the relation of the general direction of long axis of glenoid E-F to long scapular axis A-B. Figs 4, 5, 6, show also the angle at x. Figs. 1, 2, 3, schematically illustrate *thickness* of vertebral border in scapular types.



PLATE IV. 1. Gorilla. 2. Orang. 3. Chimpanzee. Scapulae in the U. S. National Museum. Each shows a wide-open long-scapular axis. Spinal angle at x. Compare with Figs. 4, 5, 6, Pl. III.



PLATE V. A "convex," a "straight" and a "concave" type of scapula illustrating the general direction of the vertebral border in each when compared with a straight edge.



## A STUDY OF THE SUPRACONDYLOID PROCESS IN THE LIVING

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The literature of variation in man forms a considerable proportion of the writings in anatomy. It is a record mainly of observations made from dissections or upon the skeleton—that is to say upon the dead remains. The period during which the records have been taken is long enough to prove that all of the more usual and obvious variations have been revealed and described in greater or less detail. Very little is known, however, about the inheritance of the long list of variations encountered in the cadavers of the dissecting laboratory. It is apparent that the examination of this dead material (bodies of persons whose family connections are unknown) is not favorable in certain respects for the pursuit of studies of inheritance. If such inquiries are to be made, some other method must be devised.

The study of the anatomy of the living is a means of approaching a solution of the problem which promises reward. Variation of superficial muscles can be observed by inspection, and many anomalies of the skeleton can be discovered by palpation. The X-ray is daily revealing to the diagnostician unexpected deviations from the normal, some of which already have aroused the suspicion of being family traits. The advantage to be derived from studying variation in a living man over that of dead material scarcely calls for mention. The objective observation which in the cadaver is limited to the form location, dimension, spatial relationship and morphological correlation of the anomaly is extended in the living into the domain of function. The individual habits may be observed. Furthermore, a subjective examination may be looked to to make known a class of phenomena that are correlated with the presence of a given variation. We already have knowledge of this sort.

The first consideration before adopting a new method should be a test of its usefulness. We have attempted in this paper to describe

our method of examining the living for the supracondyloid process and to show to what extent it may be relied upon to yield trustworthy results. As a criterion for the test, the incidence, upon which there are available figures, has been chosen.

The present work was undertaken in 1920. Materials for study were sought for in the Dispensary of the Washington University School of Medicine. By cooperation of the Dispensary Committee and staff an examining room was provided and arrangements made by which all the patients to the Dispensary presented themselves for observation. Exceptions were made in the case of infants and of adults whose condition was unfavorable for the examination. One thousand and forty persons were seen; the forty over the thousand were added to replace a like number rejected in the course of the examination because, on account of excessive fleshiness or muscularity, it was impossible to be certain of the presence or absence of the variation. Dispensary patients at random came to our examining room after having been registered at the office and assigned provisionally to a service of the clinic. The group represented the poorer element of the population of St. Louis and its suburbs. Provision was made against the possibility of examining by mistake the same patient more than once.

**Method of examining.** The examiner, seated, placed the subject, arms bared, before him and palpated in turn the left and right arm with the fingers of his right and left hands. The wrist of the subject was held by the opposite hand of the examiner and slow passive motion of the elbow was produced in order to bring about complete relaxation of the muscles of the arm. The anterior aspect of the lower one-fourth of the humerus and medial epicondylar ridge were explored in every case where this was possible. Cases were rejected when excessive fat, tense muscles or fascia interfered. When a supracondyloid process was discovered or suspected the arm was x-rayed. Sometimes three exposures were necessary to reveal the process. The plates were all made in contact with the arm and consequently little distortion resulted in the picture. The measurements of the process were made on the plates by calipers. The height of the process is its greatest projection away from the shaft of the humerus. Distance of the process above the trochlea was measured from the lowest point of the trochlea to the lower margin of the base of the process. All the processes observed were spine-formed, either moderately curved

or slightly hooked. The terms anterior, medial and intermediate refer to the position of the origin of the process from the shaft of the humerus, eg., near the anterior margin, near the medial epicondylar ridge or between these points from the antero-medial surface of the bone. A few measurements and other anthropological data of the subjects having the variation were taken in order to keep before us a picture for reference and memoranda for future use. Relative strength of pronation and supination was determined by a simple torsion spring device which the subject operated and which gave direct readings, not however sufficiently accurate to be of scientific use. The results obtained are only suggestive. This question will be carefully tested in future examinations. Materials for the study of inheritance presented themselves definitely in at least one of the families examined; the search for living relatives of all of our cases is in progress. On account of the claim of association of this variation with mental defect made by previous observers, the diagnosis of our patients was determined and inquiry and record made as to the presence or absence of mental disease in the family.

The following table represents the character of the material studied:

TABLE I.

		Males	Female	Totals
White	21 yrs. and over	244	271	515
	Under 21	71	97	168
Colored	21 yrs. and over	102	146	248
	Under 21	18	51	69
Totals		435	565	1000

## DESCRIPTION OF CASES

*Observation I.* Feb. 25, Dispensary No. A31838. Male; white; 65 yrs.; wt., 62.7 kg.; height standing 167.5 cm.; arm length (r.) 72.5 cm., (l.) 73.5 cm., forearm length (r.) 24.5 cm., (l.) 25cm., span 169.5 cm.; head length 19.2 cm., breadth 156 cm., cephalic index 81.25.



Hair-color, light brown; eye-color, light blue. Supracondyloid process, left (fig. 1); form, curved; position intermediate; 8.3 cm. above trochlea; height 3.5+ mm.; A large nerve (median?) lies behind process; a large superficial artery (brachial?) in front of process. Strength of pronation  $r.>l.$  The palmaris longus muscle is absent on the left side. Subject unmarried, parents dead; one sister and one step-sister living. Occupation, iron worker. Diagnosis syphilis.

*Observation II.* Feb. 25. Dispensary No. A33295. Male; white; 20 yrs.; laborer. Assigned to rhino-laryngology. Small supracondyloid process on left side. No further observations possible up to the time of writing.

*Observation III.* Feb. 28. Dispensary No. A34175. Female, white; 36 yrs.; wt., 58.07 kg.; height standing, 167.2 cm.; arm length (r.) 79.8 cm., (l.) 78.6 cm.; forearm length, (r.) 27 cm., (l.) 26 cm., head length 17.8 cm.; breadth 14.9 cm.; cephalic index 82.0; hair color, dark brown; eye color, blue with brown spots; supracondyloid process, left (fig. 2); form, curved; position, anterior; 6.6 cm. above trochlea, height 7+ mm.; pulse at process; nerve back of process. Palmaris longus absent, left. Subject married, but separated from husband; father dead, mother living; brothers and sisters living. Occupation, laundress; diagnosis, pulmonary tuberculosis; no family history of nervous diseases.

*Observation IV.* Mar. 2. Dispensary No. A34232. Male; colored; 42 yrs.; wt., 70.23 kg.; height standing, 172 cm.; arm length (r.) 77.5 cm., (l.) 76.8 cm.; forearm length (r.) 27 cm., (l.) 27 cm., head length 20.0 cm., breadth 15.2 cm., cephalic index, 76. Hair color, dark brown; eye color, dark brown; supracondyloid process bilateral (fig. 3, 3a); form, curved; position intermediate; right, 78 cm., left, 8.4 cm. above trochlea; height (r.) 4+ mm.; (l.) 4+ mm.; pulse at process. Nerve behind process. Strength of pronation  $r.>l.$  Palmaris longus muscle present on both sides. Subject married, no children; parents dead; 2 brothers living, married; 2 sisters, 1 living and married, other dead. Occupation, laborer. Diagnosis syphilis.

*Observation V.* Mar. 2. Dispensary No. A17146. Female; white; 30 yrs.; wt. 50.7 kg.; height standing 169 cm.; arm length (r.) 73 cm., (l.) 72 cm.; forearm length (r.) 25 cm.; (l.) 25 cm.; span 169.5 cm.; head length 18 cm., breadth 14.3 cm.; cephalic index 79.4; hair color, dark brown; eye color, blue; supracondyloid process left (fig. 4); form, hooked; position anterior; 7.7 cm. above trochlea; height

6.5+ mm.; pulse and nerve at process; strength pronation l.>r. X-ray reveals two osseous nodules just inferior to medial epicondyle (fig. 5). Subject married, not living with husband; no children. Parents both living; no evidence of supracondyloid process; 2 paternal aunts dead; 2 maternal aunts living; one examined for process, negative; subject has 4 brothers, all living; one possesses supracondyloid process, bilaterally. X-ray reveals nodule of bone adjacent to tip of medial epicondyle (epiphysis?) (fig. 6); other brothers negative; 2 sisters, one unmarried has supracondyloid process on right (table V); married sister's 2 children, negative; 4 miscarriages in subject's generation. Occupation, housewife. Diagnosis pelvic cellulitis, psychoneurosis.

*Observation VI.* Mar. 3. Dispensary No. A33076. Male; white, 33 yrs.; wt. 63.2 kg.; height standing 166.4 cm.; arm length (r.) 75.5 cm.; (l.) 74.5 cm.; forearm length (r.) 25 cm., (l.) 25 cm.; head length 19.5 cm., breadth 15.4 cm.; cephalic index 79.0; hair color, dark brown; eye color, brown; supracondyloid process left (fig. 7); form, curved; position medial; 8 cm. above trochlea; height 5.5+ mm.; pulse and nerve at process. Palmaris longus well developed. Subject's mother dead, 67 yrs.; father living, negative; 4 brothers, all dead; 3 sisters, 1 unmarried, 2 married, all negative; daughter 9 yrs. of one sister negative. Occupation, laborer; diagnosis rectal fistula; no nervous disorder in family.

*Observation VII.* Mar. 16. Dispensary No. A34938. Female;

TABLE II.

(Seven individuals presenting the supracondyloid process variation in 1,000 living subjects.)

Observ.	Sex	Color	Left	Right	Form of Spine	Height (mm.)	Age Years
I.	M	W	+	O	curved	3.5+	65
II.	M	W	+	O	?	?	20
III.	F	W	+	O	curved	7+	36
IV.	M	C	+	+	curved	r. 4+ l. 4+	42
V.	F	W	+	O	hooked	6.5	30
VI.	M	W	+	O	curved	5.5	33
VII.	F	W	O	+	curved	7.2+	41

white; 41 years; wt. 58.4 kg.; height standing 164.7 cm., arm length (r.) 75.6 cm., (l.) 74.6 cm.; forearm length (r.) 24.0 cm., (l.) 25.3 cm.; hair color, light brown; eye color, blue with brown spots; supracondyloid process right (fig. 8); form, curved; position intermediate, 7.8 cm. above trochlea; height 7.2+ mm.; Subject widow; parents dead; 1 brother and 1 sister living (not examined); 1 son, negative. Occupation, housewife. Referred to neurological clinic; no family history of nervous disease.

## INCIDENCE

In 1889 Testut<sup>1</sup> published the results of his studies on the supracondyloid process in man which included the question of its incidence. He proved that in the group examined the occurrence of the process was not so frequent as had been found by the two earlier investigators of the subject, namely, Struthers and Gruber. Since the appearance of Testut's work, reports have been made, indicating a considerably higher incidence in special groups, viz., among the insane and in criminals as stated above.

TABLE III.

Testut's eight individuals presenting the supracondyloid process variation in 929 cadavers.

Observ.	Sex	Left	Right	Length (mm.)	Age	Form
XV.	M	+		18	spine	adult
XVI.	M		+		tubercle	adult
XVII.		+	+	r. 7 l. well developed	r. triang. l. ?	13 yrs.
XVIII.	F	O	+		spine	11 yrs.
XIX.	M		+	2-3	rounded	
XX.	M	+		8	spine	50-55 yrs.
XXI.	M	O	+	4	cartilag. tubercle	35 yrs.
XXII.	F	+	O	5	triang.	adult

<sup>1</sup>TESTUT (L.)—L'Apophyse sus-epitrochléenne chez l'homme. *Internat. Monatschr. f. Anat. u. Physiol.*, 1889, VI.



Struthers<sup>2</sup> gives the incidence at 2%. He says, "As to the frequency of its occurrence in the human body, I have been in the habit of estimating that it may be found present, as more or less of a process, in about one in fifty, but not so often in its complete state as a long spur-like process." On the authority of Testut<sup>1</sup>, Gruber found the incidence to be 2.7%. Gruber's monograph<sup>3</sup> describes minutely his observations on the cadaver, but it is not clear to me how the incidence was computed. The conditions under which Testut's figure have been reached are recorded in his work published in 1889. This author examined in his laboratory at Lyon (1886-1888) 719 cadavers and found the apophysis seven times; (1888-89) 210 cadavers and two processes (Tab. III).

The figures of Nicholas<sup>4</sup> for the insane and of Valenti<sup>5</sup> for crim-

TABLE IV.

Hrdlička's classification and summary of the incidence of the supracondyloid process in 1309 humeri (654 right; 655 left) of adult whites from the dissecting laboratory of the College of Physicians and Surgeons, New York (1892-1910): Location=2.7 to 4.5 cm. above upper border of anterior fossa.

No trace of process in.....	552 = 42%	(42.17)	{ 289 r. 263 l.
Moderate roughness in its place.....	276 = 21%	(21.09)	{ 130 r. 146 l.
Pronounced roughness in its place.....	4 = 0.3%	(0.31)	{ 3 r. 1 l.
Slight ridge.....	232 = 18%	(17.72)	{ 98 r. 134 l.
Pronounced ridge in its place.....	107 = 8%	(7.72)	{ 53 r. 54 l.
Small tubercle.....	50 = 4%	(3.82)	{ 29 r. 21 l.
Pronounced tubercle in its place.....	20 = 1.5%	(1.53)	{ 12 r. 8 l.
Process (0.3 to 0.9 cm. high).....	14 = 1%	(1.07)	{ 11 r. 3 l.

<sup>2</sup>STRUTHERS (J.).—On the processus supracondyloideus humeri of Man. *Trans. Internat. Med. Cong.*, Lond., 1884.

<sup>3</sup>GRUBER (W.).—Monographie des Canalis supracondyloideus humeri. *Mém. Acad. Sci.*, St. Petersburg, 1859, III.

<sup>4</sup>NICOLAS (A.).—Nouvelles observations d'apophyse sus-épitrochléenne chez l'homme. *Rev. Biol. du Nord de la France*, 1890-91, III.

<sup>5</sup>VALENTI (G.). Processo sopracondiloideo dell' omero in due criminali ed in una pazza. *Atti e Rendic. Accad. med.-chir.* Perugia, 1896, VIII.

inals will not be discussed in this paper since they are concerned with the correlation of the variation in special groups.

A careful analysis of the occurrence of the supracondyloid process in man has been made by Hrdlička who has generously given me his unpublished results for study and comparison (Tab. IV).

As a basis for comparison of results of studies of incidence it is obvious that there should be agreement upon what constitutes a supracondyloid process and an understanding of the method used in making the calculation for incidence.

Struthers first drew attention to the common occurrence in humeri of a ridge or line at the site where the supracondyloid process presents itself. The reasons for regarding such ridges as supracondyloid process in nature are well known. Roughness at the site has also been accepted as evidence of the variation in question; it may exist alone and independent of a superimposed process or, as Testut found in one case, it may be the seat of articulation with a cartilaginous tubercle. Such a cartilaginous supracondyloid process, easily palpable, but not shown by X-ray, was found in a boy of 19 years in connection with, but not included in, the present investigation. The tubercle is also a form taken by this variation. Still another form is the triangular process, which appears to be a short spine surmounting a broad compressed base. It is necessary to the securing of reliable results that the different forms and degrees of development taken by the variation should be distinguished. The classification adopted by Hrdlička satisfies this need.

The combination of dissection and preparation of the skeleton ought to yield all data necessary for the proper identification of the variation, its form, position and degree of development. However, unless there be continuous supervision and scrutiny of the work of the students in the dissecting room the smaller processes, ridges and rough spots will pass unobserved, and would only be discovered in the examination of the prepared skeletons. Examination of the skeleton alone is sufficient for determining the incidence providing of course that the material is authenticated as to sex, race, age and symmetry. It must be remembered, however, that the occurrence of a cartilaginous process would be missed in the ordinary methods of macerating the arm bones, and that the lack of evidence given by the soft parts may leave the nature of the less typical forms of variation at the site in some doubt as to their true nature. Calculation of the

incidence by examining the arms in the living has proved to be reliable so far as the detection of a true process is concerned; however, processes less than 4 mm. in height, tubercles, rough places and ridges were only exceptionally discovered by palpation in our experience, and because of uncertainty as to their relation to the supracondyloid variation have not been recorded or otherwise included in this work.

In our 1000 dispensary patients, 7 individuals presented a supracondyloid process in the form of a spine, easily discovered by palpation and revealed by the X-ray. The incidence under the conditions of race, age and sex shown in tables I and II, of persons presenting spinous formed supracondyloid processes is 0.7%. Testut derives his figure (1%) on the occurrence of 9 apophyses in 929 subjects (table III). There were 8 individuals in the total number presenting the variation, an incidence on this basis of .8% (0.861). Eliminating the two cases presenting tubercles, the figure falls to .6% (0.645), a little less than our result which does not include the tubercular form of the process.

As there were 237 individuals under 21 years of age in our series of 1000 and none presented a palpable supracondyloid process, the incidence of individuals having the process among the total number of adults will be .9% (0.92). I do not attach much importance to this figure since it is well known that the process occurs in children. I have seen one well marked spine in the humerus of a new born child. The percentage is stated because most of the studies of the process have been upon the adult bodies of the dissecting room. The total number of adults was 763 of which 520 were white, 243 colored.

Of the 6 individuals having the variation, one was a negro; therefore somewhat over 1% (1.15) of the adult whites presented the process. The total number of negroes examined (only 243) is too small for obtaining trustworthy percentages. The presence of the variation, bilaterally, in the negro should not be accepted as proof of the occurrence, even rarely, of the supracondyloid in that race. In this instance there is some evidence of admixture of white ancestry in the family.

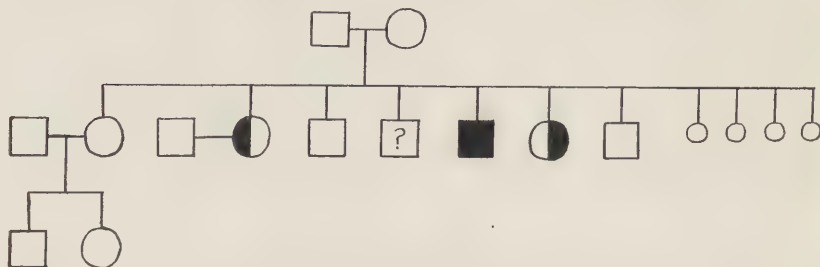
Regarding the incidence of processes in the total number of arms examined; this was 8 in 1526, or .5% (0.524). As to the number of processes in the humeri of adult whites there were found 6 in 1040, or somewhat less than .6% (0.58). This is a lower incidence than that given by Hrdlička (1.07). Some part of the discrepancy between these percentages can be accounted for by the fact that our observa-



tions do not include any spur under 4 mm. in height. Collections of humeri show that processes under 4 mm. are not rare. It is to be assumed that such small elevations were present in our group but failed of detection by palpation.

Table II represents the distribution of the supracondyloid process in respect to sex, age and symmetry in the 7 individuals in our series having the variation. What the mode of distribution may be as influenced by these factors, must await a large collection of material presenting the variation.

THE SUPRACONDYLOID PROCESS IN THE FAMILY OF A. 17146. OBSERVATION V.



SUMMARY

The paper describes an experiment in studying a well known variation by a new method of approach, that of carrying on the inquiry in the living subject.

A group of one thousand individuals taken at random from dispensary patients in St. Louis constituted the material in which the search for the supracondyloid process was made. The group was composed of whites and colored of both sexes ranging in age from 2 to 75 years. It is a fair sample of the poorer element of the City under medical care.

Record was made of the dispensary numbers of all of the subjects through which their medical histories became available. The method of examination for the variation was palpation of the arms and confirmation of observations by the X-ray. It was found possible to recognize the process form of the variation and its relation to large arteries and nerves by palpation; its position, form and approximate size by the Roentgen ray. The X-ray revealed additional features of interest in connection with the variation. Inquiry carried to members of the subjects' families which is in progress, has brought to light further evidence of the hereditary nature of the supracondyloid pro-

cess. Body measurements and other anthropological data have been secured. The possible functional bearing of the process and its possible correlation with mental defect are the subjects of inquiry upon which interesting observations have already been secured.

The reliability of the method was tested by a study of the incidence found. In attempting to compare the incidence derived by this method with the figures of previous writers from observations on the cadaver and the skeleton, an apparent great discrepancy was indicated. This discrepancy is the result both of non-conformity on the definition of the variation and on the method of computing the incidence. When figures which have been derived by similar methods of examination of the same types of process are compared a rather close agreement is found among the percentages that have been given. This is true for the results of the method used in the present work and its usefulness within certain limits (*vide infra*) is therefore demonstrated. The incidence of persons having the supracondyloid variation in the form of a process 4-7.2+ mm. in height was found to be 0.7%. The incidence of these processes in 520 pairs of arms of adult whites was 0.6-%. The figure 1% probably represents the incidence of the spine-formed process (including those of 3-4 mm.) in the humeri of the white race.







PL. I. EXAMPLES OF SUPRACONDYLOID PROCESS

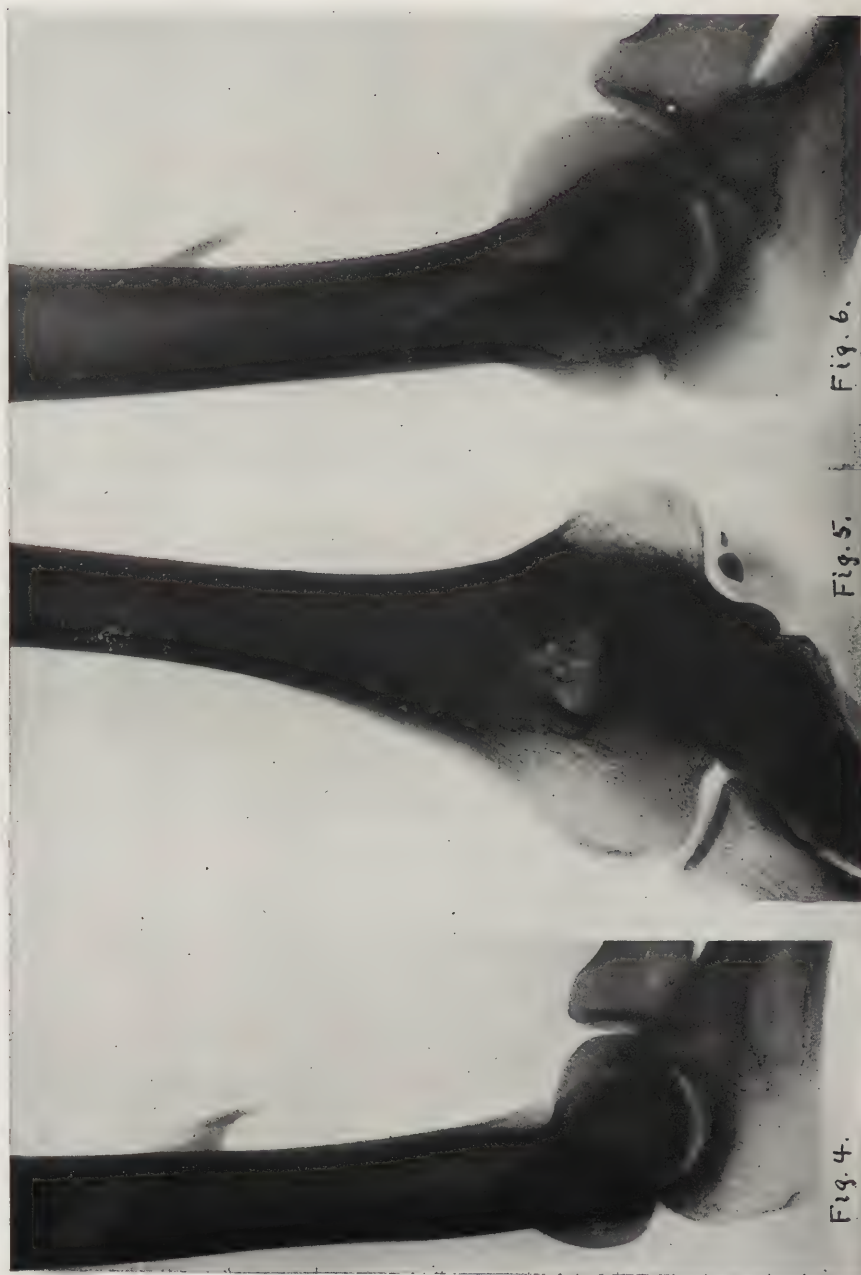


Fig. 4.

Fig. 5.

Fig. 6.

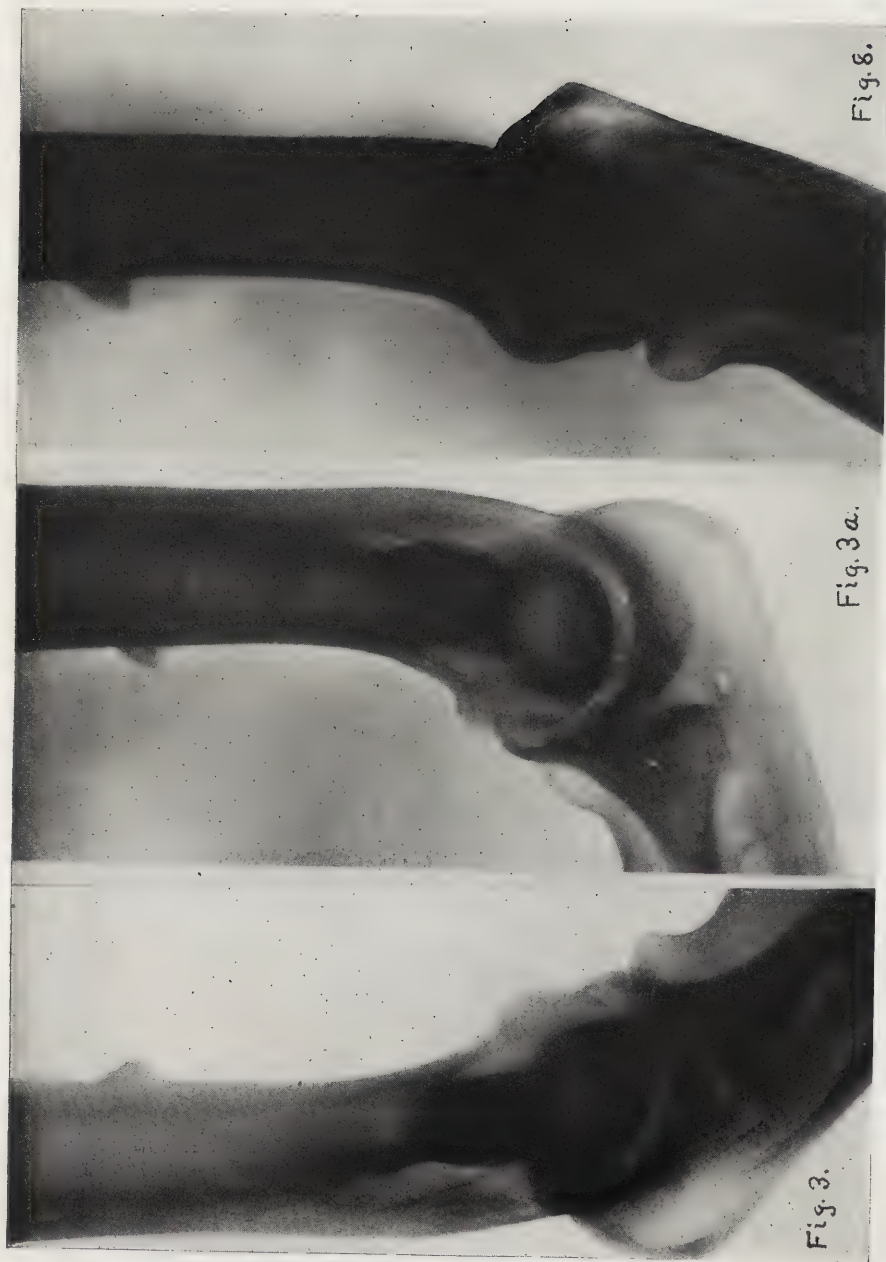


Fig. 3.

Fig. 3a.

Fig. 8.

PL. III. EXAMPLES OF SUPRACONDYLOID PROCESSES





# FURTHER STUDIES OF TOOTH MORPHOLOGY

ALEŠ HRDLICKA

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## RIDGES AND DEPRESSIONS ON TEETH

### INTRODUCTORY REMARKS

Upon closer examination of larger series of specimens, the observer will find that aside from any of the features mentioned hitherto,<sup>1</sup> the crowns and cusps of human as well as some other mammal teeth, show various additional ridges and depressions.

These ridges and depressions in some teeth look rather insignificant, in others confusing. On the teeth anterior to the premolars, they are so often absent, inconspicuous or rudimentary, that they do not convey an impression of any morphological importance, while on the bicuspid and especially the molars there seem to exist such a variety and complexity of ridges that the mind does not readily connect the conditions and associate them with those on the rest of the teeth.

A closer study of these ridges and depressions soon shows, however, that they are not mere fortuitous formations, or developed perhaps just to increase the strength or grinding efficiency of the teeth—even though these may be their main functions; but that they follow, and that on all the teeth, a definite and unique pattern, which in the course of numerous comparisons becomes more and more apparent.

<sup>1</sup>"Shovel-Shaped Teeth." *Am. J. Phys. Anthrop.*, 1920, III, No. 4, 467-475.  
*AMER. JOUR. PHYS. ANTHROP.*, VOL. IV, No. II

This primary type or design is subject to various modifications, defects, distortions and connections, in both ridges and depressions, which even in human teeth alone make its study considerably involved; in many other mammals, the masticatory surfaces, particularly in the molars, have been functionally so altered that conditions such as seen in human teeth may seem wholly absent, or can be discerned only with considerable difficulty and uncertainty. Yet there are indications, particularly on the more anterior teeth, that the fundamental tendencies of ridging and grooving are inherently alike in all mammals.

In addition to the ridges and grooves just touched upon, some premolars and molars, particularly in certain species of the anthropoid apes, show more or less of unconformable "wrinkles," which plainly are of but little morphological importance and are not classifiable.

#### LITERATURE

A survey of the literature on tooth morphology shows that the ridges and depressions now under consideration have been noticed more or less by various authors, and have even been to some extent described in detail; but that, as in the case of the rim-and-fossa formation, they have not as yet been studied sufficiently intensively and comprehensively. It is seen that as a result these formations are still known but imperfectly; that their significance has not as yet been clearly established; and that in some cases they have received a wrong interpretation.

The quoting of all the literature bearing upon these ridges and depressions would be difficult as well as confusing. The best notes on the subject are found in Black, an American author whose work seems to have remained unknown to the Europeans, and in Mühlreiter, a prominent German odontologist. Writing originally in the late eighties Black speaks thus of these formations: <sup>1)</sup>

(P. 25). *Upper Median Incisors*.—"Developmental Lines. When any of the incisors first appear through the gums there are three little eminences or *tubercles*, called mammelons, on the cutting edge, with *grooves* crossing from labial to lingual side between them. These grooves run some distance on the labial surface, becoming broader and shallower till they disappear. In many, these lines appear on the

<sup>1</sup>BLACK, (G. V.), *Descriptive Anatomy of the Human Teeth*. 3rd. ed., Phila., 1894; also 2nd ed., 1891.



lingual surface between the marginal ridges and the fossa. Occasionally they are seen as far as the linguo-gingival ridge. . . . These lines divide this part of the crown of the tooth into three *labial* lobes. Calcification begins in these mammelons as separate pieces, or plates, and the grooves are the marks of the after-confluence of these plates." . . .

(P. 29). *Upper Lateral Incisors*.—"The cutting edge, at the time of eruption presents three tubercles, or mammelons, and the grooves crossing the edge between these are projected on the labial surface as shallow labial grooves" . . . .

(P. 34). *Canines (Upper); Labial Surface*.—"The greater convexity mesio-distally is caused by a strong labial ridge running from the point of the cusp to the gingival line. This ridge occupies so much of the surface of the tooth that its margins are imperfectly defined. It belongs to the middle lobe, developed from the middle plate which, in the incisors, is the smallest of the three, but in this tooth is much the largest. There are two labial furrows, or a flattening of the convexity between the central line of the ridge and each angle, marking the junction of the lobes. These furrows are usually lost by becoming shallower before reaching the centre of the length of the crown" . . . .

(P. 37.) *Upper Canines, Lingual Surface*.—"Mesio-distally this surface is slightly convex in its central part on account of the lingual ridge which runs from the point of the cusp nearly, or quite, to the cingulum. On each side of this and between it and the marginal ridges, there is a slight but well-defined concavity and furrow, marking the confluence of the lobes. The marginal ridges arise from the mesio- and disto-incisal angles and unite with the linguo-gingival ridge or cingulum. These ridges are usually large near the angles, and much less pronounced toward the linguo-gingival ridge. The latter is prominent, and is often raised into a tubercle, or slight cusp. Occasionally this part of the enamel is thrown into irregular folds with grooves between, which are sometimes fissured. More rarely the small cusp may be divided by a groove" . . . .

(P. 41). *Lower Canines, Lingual Surface*.—"The developmental lines, or grooves, are the same as those of the upper cuspids, but less prominent. Yet, generally, they can be seen in unworn teeth. Fissures are seldom seen in any part of this tooth." . . .

(P. 42). "*The Bicuspid*s, although unlike the incisors and cuspids in the contour of their crowns, have the same number and a similar

distribution of primary parts or *lobes*. They are, indeed, formed on the same general plan. The change of form is the result of a different relative development of the parts by which the cingulum, or linguo-gingival ridge, is elevated into a powerful *lingual cusp*; which, in the upper bicuspid, is almost or quite as high as the buccal cusp, but in the lower bicuspid, especially in the first, is less prominent. The middle lobe also forms a relatively larger part of the buccal portion of the crown than in the incisors and cuspids, while the mesial and distal lobes are relatively smaller. By the development of the lingual cusp of the upper bicuspid, the linguo-gingival grooves of the incisors and cuspids is carried to the central part of the crown, which it traverses from mesial to distal in a deep sulcus. It is naturally divided, by the mesial and distal pits found at its junction with the triangular grooves, into three parts; mesial, central and distal. In the lower bicuspid the lingual lobe is often very small and the course of the grooves irregular" . . .

(P. 45). *Upper 1st Bicuspid, Buccal Cusp*.—"The buccal cusp is the larger, and forms the terminal point of the buccal surface. From the point of this cusp, four ridges lead away at right angles. Two of these form cutting edges, which slope away mesially and distally to the mesio-bucco-occlusal and disto-bucco-occlusal angles, where they join the mesial and distal marginal ridges. The central buccal ridge leads away centrally on the buccal surface toward the gingival line, forming the convexity of this surface. The triangular ridge slopes down to the central part of the crown and joins a similar ridge from the lingual cusp to form the transverse ridge or ends in a central sulcate groove" . . .

*Lingual Cusps*.—"The lingual triangular ridge leads down from the central point of the cusp to the central groove, to join its fellows from the buccal cusp in the formation of the transverse ridge, or is divided from it by a deep central sulcate groove. This ridge is seldom prominent. Very frequently the central incline of the lingual cusp is a plain surface.

"The *mesial* and the *distal* marginal ridges are strong ridges of enamel which rise in the mesial and distal terminations of the cutting edges of the buccal cusp, and form the mesial and distal margins of the occlusal surface. They join with the ridge forming the lingual cusp; or they are usually divided from the latter by the mesial and

distal grooves; though these grooves are often indistinct, especially in teeth that have been somewhat worn.

"The occlusal surface of the bicuspid have five *developmental grooves*; the central, mesial, distal, mesial triangular and distal triangular. The central groove is deeply sulcate, and divides the triangular ridges, or passes over their junction as a shallow line, and sinks into a triangular pit at either end. The mesial and distal grooves are really continuations of the central, which pass over the marginal ridges as very fine lines or as more definite grooves, and mark the boundary of the lingual lobe. They are rarely fissured while the central groove is frequently fissured throughout its course. The triangular grooves, mesial and distal, run from the mesial and distal pits toward the mesio-buccal and disto-buccal angles, dividing the marginal ridges from the triangular. They are occasionally sulcate in the first part of their course and are generally lost toward the mesio- and disto- buccal angles by becoming shallower, but in young unworn teeth they can often be followed as a fine line running over the cutting edges of the buccal cusp near the angles, and leading into the buccal grooves. These are the marks of confluence of the mesial and distal lobes with the middle lobe. In the central incline of the lingual cusp, supplemental grooves are often seen meeting the triangular grooves of the buccal side. The triangular grooves are occasionally fissured for a short distance from their junction with the central."

(P. 50). *Upper 2nd Bicuspid*.—"The general form of the *occlusal surface* is similar to the first bicuspid. It presents a buccal and lingual cusp, and similar sulcus, ridges, grooves and pits. The average height of the cusps is considerably less than in the first bicuspid. The marginal ridges are proportionately broader, the mesial and distal pits closer to each other and the central groove shorter. The triangular grooves join the central groove nearer the mesio-distal center of the tooth, making the buccal triangular ridge narrower and more nearly pointed. In many examples the enamel of the occlusal surface is thrown into several shallow wrinkles, or supplemental grooves and ridges, which radiate from the central groove, which occurs but rarely in the first bicuspid."

(P. 53). *Lower First Bicuspid*.—"The buccal cusp presents the same ridges leading from its summit as described for the upper first bicuspid, but the pair which form the cutting edges usually form a



curve with its convexity to the buccal, and merge into the marginal ridges by more rounded angles. The buccal triangular ridge is narrow and prominent and joins the elevated lingual ridge or cusp forming a complete transverse ridge. In many instances this is deflected to the mesial or distal. In young teeth, the central groove often crosses the transverse ridge as a fine line, which soon disappears by wear. However, in many examples the transverse ridge is divided by a deeply sulcate groove. There is a deep pit at the mesial and the distal ends of the central groove, or on either side of the transverse ridge from which the triangular grooves, which divide the marginal ridges from the triangular, or transverse ridge, run toward the mesio- and disto-buccal angles. These are often sulcate in the first part of their course. In many young teeth these grooves may be traced over the cutting edges on to the buccal surface, marking the confluence of the central with the mesial and distal buccal lobes." . . .

(P. 55). *Lower Second Bicuspid*.—"The lower second bicuspid is a little longer than the lower first, and of much the same figure, except that the lingual cusp is proportionately higher and more nearly, but never quite, on a level with the buccal, but the lingual surface is about equal to the buccal in mesio-distal breadth. These teeth are regular in general contour, but the grooves of the occlusal surface are much diversified. These differences may be classified under three forms: 1st, The central groove joins the triangular grooves in such a way as to form a half circle with the convexity to the lingual, with or without a transverse ridge crossing its line. In these, when the transverse ridge is high, only a deep pit appears on either side. 2nd. The lingual cusp is divided by a sulcate groove, which runs over centrally, or nearly so, to the lingual surface, making a three-cusped tooth. The central groove forms an angle at the junction with the lingual, or is crescentic in form. It joins with the triangular grooves in such a way that the point of junction cannot be told except by finding the mesial and distal grooves, which are often very indistinct. 3rd. The central groove is straight and generally sulcate with a deep pit at each end. In many examples, these pits are crossed by the triangular grooves almost at right angles with the central. By tracing the fine mesial and distal grooves carefully in young unworn teeth, it will be found that the lingual lobe is much larger than in the lower first bicuspid, and almost as large as in the upper bicuspids. In the

three-cusped forms the two lingual lobes are usually a little broader from mesial to distal than the buccal portion of the tooth."

Black makes also an effort to describe the ridges on the molars, but fails to recognize their identity and describes them as if they belonged to the whole tooth rather than to individual cusps. He calls the median ridge of each cusp the "triangular ridge." His illustrations also fail to convey the standard pattern.

The next, in time, American name of prominence in research on teeth is that of Wortman. This author has published a number of valuable contributions to Odontology both human and comparative, and he has noted some of the ridges and depressions on the teeth, but like others, has never given these features a special attention. In his "Comparative Anatomy of the Teeth of the Vertebrata" (American System of Dentistry, 1886) we find the following remarks bearing on the points under consideration:

There is nothing about the ridges and furrows in incisors:

(P. 441). *Canines*.—"In the superior canines a slight ridge descends upon the external or labial face from the summit of the terminal cusp to the neck, but is absent in the corresponding teeth below" . . .

"The palatine convexity is occasioned by a well-marked vertical ridge which extends from the summit of the terminal cusp to the cingulum below; this latter structure is usually well defined, being stronger in the upper than in the lower teeth" . . .

(Pp. 442-443). *Inferior Premolars*.—"Two strong cusps of which one is external and the other internal, occupy the grinding face, and are separated by a deep notch or valley, deepest in the centre. The anterior and posterior margins of this valley are bordered by slight ridges which connect the anterior and posterior extremities of the cusps; the anterior of these is a little more elevated than the posterior and forms a useful guide in determining the mesial and distal surfaces of the tooth, and consequently the side of the jaw to which it belongs. In some instances the enamel forming the floor of the valley and adjacent sides of the cusps and ridges is quite smooth, but most frequently it is considerably wrinkled and thrown into a number of minor cusps and ridges, with intermediate indentations which offer receptacles for the lodgment of food" . . .

"The internal vertical ridge of the external cusp, joins this cingulum near its central portion, leaving a deep pit upon either side,

where the destructive agencies of decay on the crowns of these teeth exhibit themselves most frequently. The degree to which this vertical ridge is developed is subjected to great variation; it may be almost entirely absent in some individuals or strongly developed in others. The crown of the second or posterior bicuspid or premolar is more quadrate in outline than the anterior or first; the internal cusp is better developed, and frequently shows a tendency to form two."

Other American and English investigators on teeth, such as Cope, Tomes, Osborne, Scott, Gidley, Gregory, Woodward and others have in general paid attention only to the crowns and cusps as a whole, to the sulci separating the different cusps, and to the secondary ridges connecting some of the cusps, in the human and primate teeth. They have studied the teeth from a different standpoint, with attention concentrated on the gross forms, and on the origin, identities and homologies of the various cusps, rather than on the finer modelling, which in relation to these larger problems must have appeared of very subsidiary importance.

Among authors of other countries, the first place in this connection belongs to those publishing in German, and the foremost in this line are Mühlreiter, Zuckerkandl, Rose, Kükenthal, and more recently Schlosser, Walkhoff, Adloff, de Terra, Bolk and Stehlin. With these investigators too, attention so far has been concentrated essentially on the larger features of the teeth; notwithstanding which however the finer features received also more or less consideration. This especially by Mühlreiter and Zuckerkandl.

Zuckerkandl, in his classic "*Anatomie der Mundhöhle mit besonderer Berücksichtigung der Zähne*" (8°, Vienna, 1891), has the following to say about the ridges and depressions observable on the human teeth:

(P. 34). *Upper Median Incisors. Labial Surface.* "In strongly developed teeth the labial surface shows two shallow furrows which begin at about the middle of the crown and extend longitudinally to the cutting edge of the tooth" . . . .<sup>1</sup>

<sup>1</sup>(P. 34). *Upper Median Incisors. Labial Surface.* "Bei kräftig gebildeten Zähnen ziehen an der Lippenfläche zwei seichte Längsfurchen bis an die Schneide hinab, die in halber Kronenhöhe beginnen. Sie theilen die Schneide in drei Zacken, welche bald nach dem Durchbruche der Zähne durch Abnutzung verloren gehen." . . . .

(P. 35). *Upper Median Incisors. Lingual Surface.* "(a.) Die linguale Zahnfläche ist, vom schmalen Saume abgesehen, blos ganz leicht vertieft, und an



(P. 35). *Upper Median Incisors. Lingual Surface.*—On this surface “(a) are found three grooves, two of which begin immediately below the tubercle. These grooves end on the cutting edge, and give rise to the formation of several longitudinal ridges.

“(b) There proceed from the tubercle one to two ridges which gradually become flatter until they disappear on the lingual surface.”

“(e) The tubercle is prolonged, at the same time becoming gradually less prominent, up to the cutting edge of the tooth. Between this prolonged ridge and the elevated lateral borders on each side is formed a small depression.”

(P. 39) *Lower Median Incisors.*—“The upper half of the labial surface on freshly erupted teeth, shows two longitudinal grooves which end in depressions in the cutting edge giving rise to three small cusps.”

(P. 42).<sup>1</sup> *Upper Canines.*—“Laterally near the border on each side there is found in most cases a small furrow-like depression or groove by which the median enamel ridge which runs from the neck to the point of the tooth is even more accentuated.”

(P. 45).<sup>2</sup> *Upper Premolars.*—“The masticatory surface of the buccal cusp is strongly convex and branching from the transverse furrow shows not seldom two short lateral depressions, through which the surface of the cusp is subdivided into several ridges. The middle of these is usually the stoutest. The corresponding surface of the lin-

derselben finden sich drei Furchen, von welchen zwei unmittelbar unterhalb des Tuberculum beginnen (Fig. 8D). Die Furchen endigen oberhalb der Schneide und geben Veranlassung zur Bildung von mehreren Längswülsten.

(b.) “Vom Tuberculum gehen ein bis zwei Wülste aus, die allmähig sich verflachend an der Zungenfläche verschwinden (Fig. 8B).” . . .

(e.) “Das Tuberculum verlängert sich, dabei allmähig flacher werdend, bis gegen die Schneide hin. Zwischen dem verlängerten Wulste und dem aufgeworfenen seitlichen Rande etabliert sich je ein Grübchen.” . . .

(P. 39). *Lower Median Incisors.* “Die Lippenfläche ist wenig gewölbt und an eben durchgebrochenen Exemplaren (in der oberen Zahnhälfte) mit zwei Längenfurchen versehen, die an der Schneide Einkerbungen erzeugen und zur Bildung von drei Zacken Veranlassung geben.” . . .

<sup>1</sup>(P. 42). *Upper Canines.* “Seitliche nahe den Rändern finden sich zumeist kleine furchenförmige Vertiefungen oder Grübchen (siehe Fig. 13B) durch welche die mittlere Schmelzleiste, welche vom Hals gegen die Spitze herab verläuft, noch um so stärker herausgearbeitet erscheint.” . . .

<sup>2</sup>(P. 45). *Upper Premolars.* “Die Kaufläche des buccalen Höckers ist stark gewölbt und zeigt nicht selten zwei seitlich gestellte, aus der Querfurchen abzweigende kurze Rinnen, durch welche die genannte Höckerfläche in mehrere Nebewülste zerlegt wird. Der mittlere von diesen ist dann gewöhnlich der breiteste. Die Kaufläche des lingualen Höckers ist gleichfalls stark gewölbt und secundäre Furchen an derselben werden auch hin und wieder beobachtet.” . . .

gual cusp too, is strongly convex, and here and there will also show secondary furrows."

(P. 49).<sup>1)</sup> *Lower Premolars*.—"The two cusps are connected by a narrow enamel ridge . . . . The Masticatory surfaces of the cusps show on each side between the median ridge and the elevated lateral border, a rounded depression."

In dealing with the molars, Zuckerkandl devotes his attention to the number of cusps and to the main furrows. His only remark concerning the ridging of the cusps is as follows:

(P. 60).<sup>2)</sup> *Molars*.—"The masticatory surfaces of the cusps are convex, and frequently such a surface, or even all of them, is subdivided by secondary grooves into small ridges.

Mühlreiter, while in the main following Zuckerkandl, goes considerably further in certain particulars, and presents on the whole the best non-English contribution to our knowledge of the more detailed tooth modeling. In the third edition of his "*Anatomie des menschlichen Gebisses*" (Leipzig, 1912; also second edition, 1891), we read as follows:<sup>3)</sup>

(P. 18). *Upper Median Incisors*.—"Only a few upper median incisors have a completely smooth labial surface. In the majority of cases there may be noted on these surfaces a slight longitudinal marking or folding. This consists usually of three, sometimes barely traceable, sometimes well pronounced, but always only slightly elevated longitudinal ridges, between which exist two shallow main grooves, which begin about the middle of the crown, run to the cutting edge and divide the latter in unworn teeth into three rounded little cusps."

<sup>1</sup>(P. 49). *Lower Premolars*. "Die Spitzen der beiden Höcker sind durch eine schmale Schmelzleiste untereinander verbunden. . . . Man findet demnach an der Kaufläche, zu beiden Seiten der Mittelleiste und randständig von den Seitenwülsten begrenzt, rundliche Grübchen."

<sup>2</sup>(P. 60). *Molars*. "Die Kauflächen der Höcker fallen von den Zackenspitzen mit gewölbten Flächen gegen die Kreuzfurche ab und häufig sind einzelne der genannten Flächen, seltener sogar alle, durch Nebenfurchen in kleinere Wülste getheilt."

<sup>3</sup>(P. 18). "Wenige obere Zentralschneidezähne haben eine vollkommen glatte Lippenfläche. Bei der Mehrzahl gewahrt man an der letzteren eine zarte Längsstreifung oder Faltung, welche ihrem Grundzüge nach gewöhnlich aus drei bald nur angedeuteten, bald deutlich ausgeprägten, aber immer nur schwach erhabenen Längleisten besteht, zwischen welchen zwei seichte Hauptfurchen, ungefähr in der halben Kronenhöhe beginnend, bis zur Schneide herablaufen und letztere bei intakten Kronen in drei abgerundete Zacken teilen." . . . .

(P. 20). *Upper Median Incisors. Lingual Surface.*—"More frequently [than a complete lack of modeling] there are met with three (exceptionally also two or four) more or less shallow grooves, running parallel and without break, hence similarly as on the labial surface, from the tubercle to the vicinity of the cutting edge; and these grooves are accompanied and respectively bounded by two weakly pronounced median and the two marginal ridges.

Still more frequently however,<sup>1)</sup> the two median ridges which immediately after their origin from the tubercle are somewhat more prominent and more sharply defined, will diminish and after a short course, run to a point, while the remaining concave part of the lingual surface up to the cutting edge retains the ordinary faint grooving. The tubercle appears thereby in its distal part provided with two short independent folds or ribs."

Curiously enough, the artist who drew the eight teeth in Mühlreiter's Fig. 4, represented in four of these a triple, instead of a double lingual ridge, which seems to have escaped the author's attention.

(P. 37). *The Canines.*—The labial surface shows a dull vertical ridge . . .

(P. 38). The lingual surface is divided into two by a prominent median ridge which reaches from the tubercle to the point of the tooth. "Between this median ridge and the usually equally well developed marginal ridges, there is found on each side a furrow-like depression" . . .

Speaking of some aberrant forms, Mühlreiter says:

(P. 39). "Especially characteristic of this form of the crown is the

(P. 20). *Upper Median Incisors. Lingual Surface.* "Häufiger ist jedenfalls die unter A (Fig. 4) abgebildete Form anzutreffen. Es ziehen parallel zueinander drei (ausnahmsweise auch zwei oder vier) mehr oder minder seichte Furchen ohne Unterbrechung, also ähnlich wie an der Lippenfläche, vom Tuberkulum ausgehend bis in die Nähe der Schneide und werden begleitet resp. begrenzt von zwei schwach ausgeprägten Mittelleisten und den beiden Randleisten.

(P. 37). *The Canines.* "An der Lippenfläche ist insbesondere die Querwölbung in der Halsgegend viel bedeutender, als bei den Schneidezähnen; in der unteren Hälfte dieser Fläche wird indessen die starke Rundung dadurch unterbrochen, dass von der Mittelspitze eine stumpfe Längenzeile abgeht, die, nach oben schwächer werdend, sich alsbald gänzlich verliert, diese untere Partie der labialen Fläche aber in zwei mehr minder plane Facetten teilt.

(P. 38). Die Zungenfläche "wird durch eine, jedoch kräftig hervorgewölbte, von dem Tuberkulum bis zur Spitze reichende, in gleicher Richtung gar nicht oder nur schwach konkave Längenzeile in zwei Hälften geteilt. Zwischen der Mittelleiste und den gewöhnlich ebenfalls gut entwickelten Randleisten befindet sich je eine furchenförmige Vertiefung, die bei einigermaßen vorgeschrittener Abnutzung in ein seichtes, ovales Grübchen umgewandelt wird." . . .



almost constant occurrence besides the median ridge of a second, even though shorter longitudinal elevation, on the part of the surface between the median ridge and the border of the tooth, and separated from the median ridge as well as from the terminal part of the marginal ridge by a more or less deep depression."<sup>1)</sup>

(P. 48). *Upper Premolars*. The masticatory surface of the buccal cusp is frequently provided, especially near the point, with a prominent median ridge. A similar ridge, but generally less marked, is seen in corresponding location on the lingual cusp. Besides this, as "Zuckerkanndl very properly remarks, not seldom there appear on both sides of the masticatory surface also several secondary ridges, separated from the stouter median ridge by small secondary grooves radiating from the main furrow between the two cusps. This is an expression of the same folding which appears with such a predilection on the lingual surface of the upper front teeth, and which shows the masticatory surface of the buccal cusp of the upper pre-molars to be topographically identical with the lingual surface of the incisors and canines.

"In individual cases the folding extends also to the lingual cusp, and the whole masticatory surface of the teeth appears then ridged, with grooves radiating between the ridges."<sup>2)</sup>

<sup>1</sup>(P. 39). "Besonders kennzeichnend für diese Kronenform ist das fast konstante Auftreten einer zweiten, wenn auch kürzeren Längenzeile neben der mittleren, welche den zwischen der letzteren und der distalen Ecke gelegenen Teil der Zungenfläche okkupiert und sowohl von der Mittelleiste wie vom Ende des Randwulstes durch eine mehr minder tiefe Einkerbung getrennt wird."

(P. 48). *Upper Premolars*. "Kaufläche. Die beiden Höcker sind verhältnismässig kräftig und ziemlich gleichmässig entwickelt, die schärfere Spitze des bukkalen Höckers überragt nur wenig jene des lingualen. Die stark gewölbte und steil abfallende Rückwand des ersteren—die Wangenzone der Kaufläche—ist häufig, besonders an der Spitze, mit einer prominierenden Mittelleiste versehen, die an der entsprechenden Fläche des Zungenhöckers gewöhnlich etwas schwächer markiert ist. Sehr richtig bemerkt Prof. Zuckerkanndl, dass nicht selten an beiden Zonen der Kaufläche mehrere Nebenwülste auftreten, welche durch sekundäre, aus der Hauptfurche abweigende Rinnchen von der breiteren Mittelleiste getrennt werden. Es spricht sich hierin dieselbe Faltenbildung aus, welche an der Zungenfläche der oberen Frontzähne so gern vorzukommen pflegt und durch welche die Kauflächenzone der oberen Prämolarkörper sich als topographisch identisch mit der Zungenfläche der Schneide und Eckzähne erweist.

<sup>2</sup>An einzelnen Exemplaren erstreckt sich ferner die Faltung auch auf die Seitenwülste, und es erscheint dann die Kaufläche von einem Kranze von Fältchen eingesäumt, deren Zwischenfurchen strahlenförmig auslaufen."

(P. 58). *Lower Premolars*.—"Similarly as in the upper bicuspid, the masticatory surface of the buccal cusp of the lower bicuspid shows also, as a rule, a prominent and steep median ridge, accompanied fairly frequently on the distal part of the surface, but only very seldom on the mesial part, by a secondary ridge."

(P. 69). "In the folding of the masticatory surface of each cusp of the molars is found an expression of the same architectonic type we have seen on the cusps of the premolars and which in general is proper to every cusp occurring on the human teeth. A strongly prominent, fairly broad and very often bevelled median ridge proceeds steeply from the point of the cusp to its base, and is separated by secondary grooves from the small lateral ridges which run into the borders of the cusp and represent so to say the marginal ridges proper to each cusp. It is self understood that there are many variations in the degree of development of these various features and that these can only be studied on intact, unworn teeth."

Regrettably there are no illustrations of this pattern, and the author attempts no deductions as to its significance.

Wortman, in his "Comparative Anatomy of the Teeth of the Vertebrata" (*Am. System of Dentistry*, 1886), has nothing to say about ridges and furrows on the incisors. As to other teeth, there are the following notes:

(P. 441). *Canines*.—"In the superior canines a slight ridge descends upon the external or labial face from the summit of the terminal cusp to the neck, but is absent in the corresponding teeth below."

"The palatine convexity is occasioned by a well-marked vertical ridge which extends from the summit of the terminal cusp to the

(P. 58). *Lower Premolars*. "Ganz ähnlich wie bei den oberen Backenzähnen besitzt auch die Kauflächenzone des Wangenhöckers in der Regel eine stark prominierende und steil abfallende Mittelleiste, zu welcher sich ziemlich häufig an dem distalen Abschnitte, aber nur höchst selten an dem mesialen eine Nebelleiste gesellt."

(P. 69). *Upper Molars*. "An der Kauflächenzone eines jeden einzelnen Höckers spricht sich in der Faltenbildung dasselbe architektonische Gepräge aus, das wir an den Höckern der Prämolaren bereits kennen gelernt haben und das überhaupt jedem an den menschlichen Zähnen auftretenden Kronenhügel zu eigen ist. Eine stark prominierende, verhältnismässig breite und sehr oft gratartig zugeschärfte Mittelleiste zieht in steilem Abfalle von der Spitze bis zum Fusse des Höckers und wird jederseits durch ein sekundäres Rinnchen von den beiden zarten Nebenfältchen getrennt, welche in die Hügelränder auslaufen und sozusagen die proprietären Randleisten des einzelnen Höckers repräsentieren. Selbstverständlich machen sich in dem Grade der Ausbildung dieser Einheiten mannigfache Schwankungen geltend und können dieselben überhaupt nur an intakten, nicht abgenützten Zähnen studiert werden." No good illustration of this pattern. No deductions.

cingulum below; this latter structure is usually well defined, being stronger in the upper than in the lower teeth" . . .

(Pp. 442-443). *Inferior Premolars*. "Two strong cusps of which one is external and the other internal, occupy the grinding face, and are separated by a deep notch or valley, deepest in the centre. The anterior and posterior margins of this valley are bordered by slight ridges which connect the anterior and posterior extremities of the cusps; the anterior of these is a little more elevated than the posterior and forms a useful guide in determining the mesial and distal surfaces of the tooth, and consequently the side of the jaw to which it belongs. In some instances the enamel forming the floor of the valley and adjacent sides of the cusps and ridges is quite smooth, but most frequently it is considerably wrinkled and thrown into a number of minor cusps and ridges, with intermediate indentations which offer receptacles for the lodgement of food." . . .

"The internal vertical ridge of the external cusp, joins this cingulum near its central portion, leaving a deep pit upon either side, where the destructive agencies of decay on the crowns of these teeth exhibit themselves most frequently. The degree to which this vertical rib is developed is subjected to great variation; it may be almost entirely absent in some individuals or strongly developed in others. The crown of the second or posterior bicuspid or premolar is more quadrate in outline than the anterior or first; the internal cusp is better developed, and frequently shows a tendency to form two."

*Molars*. Nothing about cusp ridges—author barely touches upon "corrugation."

Tomes, in his "Manual of Dental Anatomy" (6th ed., London, 1904), has even less to say about the ridging and grooving of teeth than Wortman. His principal remarks in this connection are:

(P. 579-580). *Canines*. "The crown terminates in a blunt point, which lies in a straight line with the long axis of the root; a feebly pronounced line or ridge runs down the outer surface of the tooth from this point to the neck . . . The internal or lingual surface is not concave like that of the incisors, but is in a slight degree convex, and a median ridge runs down it from the apex of the cusp; this ridge where it meets with the ridge which borders the lingual surface and corresponds with the cingulum of the incisor teeth, is often developed into a well-marked prominence or slight cusp" . . .

On the lower canines "the perpendicular labial ridge is not trace-



able, and the want of symmetry between the mesial and distal halves of the crown less marked." . . .

(P. 581). *Premolars, Upper*. "It is, however, not uncommon, especially in the lower races of mankind, to see some indication of a median ridge upon the labial surface, defined by slight grooves upon either side" . . .

But little besides the above:

(P. 584). "A longitudinal section through the crowns of the two teeth will demonstrate without the necessity of further description that the basal cusp of the canine and the inner cusp of the bicuspid are the same thing, differing only in degree, while it is interesting to note that the pulp chamber in the bicuspid has hardly any prolongation towards the small inner cusp, so that the resemblance between the two teeth is thus made more complete" . . .

"The transition from the bicuspid to the molars is more abrupt; at least it is not so easy to point out exactly how the cusp pattern of the one would arrive at the form of the other. But it merely needs an exaggeration of the differences existing between a canine and a first bicuspid to make a good imitation of a second bicuspid.

"If any one will take the trouble to make mental note of the deviations in form which he meets with even in human teeth, he will find that they almost invariably consist of approaches towards the form of the teeth on either side of them; and will infallibly be led to the conclusion that incisors, canines and bicuspid are not three patterns of teeth perfectly distinct, and each *sui generis*, but that they are modifications of one and the same pattern."

Tomes has nothing to say about the ridges on the cusps of the molars, mentioning only the connecting ridge between the *ai* and the *pe* cusps of the upper molars.

In 1898, Selenka, in his "Menschenaffen,"<sup>1</sup> calls attention to the occurrence of various wrinkles or ridges on the lingual surface of the incisors of the orang<sup>2</sup> but without distinguishing any special constit-

<sup>1</sup>SELENKA (E.), Rassen, Schädel und Bezeichnung des Orangutan; 6 Heft, Wiesbaden, 1898, p. 57, figs. 82, 83.

<sup>2</sup>"Sämtliche Zähne des Orangutan, sowohl der ersten wie zweiten Dentition, tragen ein ganz eigenartiges Gepräge, welches sie von den Zähnen der übrigen Affen unterscheidet; man kann sie daher, solange sie nicht stark abgekaut sind, fast ausnahmslos als Orangutanazähne erkennen. Dieses spezifische Merkmal besteht vor allem in den zahlreichen Schmelzrunzeln, welche bei Schneide- und Eckzähnen auf der lingualen (Innen-) Fläche, bei allen Backzähnen auf der

uent. His illustrations however, show plainly the existence of a double (main) central vertical ridge on both the temporary and the permanent median upper incisors which he pictures, and of one marked median vertical ridge on each of the two lower medians (1 temporary and 1 permanent) and the three laterals (lower temporary, upper and lower permanent) which are included in his plate. In addition all these teeth show more or less redundancy of the enamel borders of the lingual surface and a corresponding approach to the shovel-shaped conformation.

A year later, in describing the teeth of the gorilla and chimpanzee,<sup>1</sup> Selenka reports a wrinkling of the lingual surface of the incisors in both of these forms, also, but here again goes into no details or analysis of the various ridges.<sup>2</sup> The illustrations show a single stout median ridge on each of the temporary upper median incisors of a young chimpanzee (p. 111, fig. 14, C); a single median ridge on each of the permanent upper incisors, and an even better developed such ridge on each of the lower incisors as well as the canines, in an adult female chimpanzee (p. 112, fig. 117); a single median ridge on the two upper median and on all the lower incisors of a juvenile orang,

Kaufläche liegen . . . Bisweilen traten Längsriefen auch auf der labialen (äusseren) Fläche der Schneidezähne, seltener der Eckzähne auf. Regelmässig zieht eine tiefe Längsfurche auf der vorderen Seite des oberen, und auf der hinteren Seite des unteren Eckzahns der ganzen Krone entlang."

<sup>1</sup>Ibid. Heft 7, 1899.

<sup>2</sup>"Sämtliche Zähne des Orangutan sowohl der ersten wie der zweiten Dentition, tragen einen eigenartigen Stempel, welcher sie von den Zähnen ihrer Verwandten unterscheidet: Schneide- und Eckzähne zeigen auf der Innen- oder Lingualfläche deutliche Längsrünzeln, die Kaufläche der Backzähne und der oberen inneren Schneidezähne zahlreiche feine unregelmässige Rünzeln. Im intakten Zustande kann daher bei einiger Übung jeder Orangutan-Zahn als solcher erkannt werden, ausgenommen etwa die unteren äusseren Incisivi des Milchgebisses, deren Rünzeln bisweilen nur schwach hervortreten (vergl. Seite 60-61), sodass sie den gleichnamigen Zähnen des Schimpanse gleichen können.

Milch- und Dauerzähne des Schimpanse ähneln überhaupt denen des Orangutan; denn auch bei jenen sind die Innenflächen der Schneide- und Eckzähne mit Längsrünzeln, die Kronflächen der Backzähne mit unregelmässigen Rünzeln besetzt; aber diese Rünzeln sind stets spärlicher und schwächer ausgeprägt als auf den Zähnen des Orangutan. Die Milchschneidezähne des Schimpanse erscheinen nämlich auf der Lingualfläche meistens nur schwach gerieft . . . Die Dauerzähne sind immer gefurcht und gerünzelt, am stärksten die Molaren. . . . Auf der Innen- und stets deutlich auf der Aussenfläche der Milchschneidezähne verlaufen beim Gorilla sehr schwache Furchen oder Riefen; Rünzeln fehlen ihnen jedoch . . . Die Dauerzähne des Gorilla (Seite 75, Seite 135 bis 144) zeigen folgendes. Die Incisivi sind auf der Lingualfläche mehr oder weniger stark mit Längsfurchen versehen, die Canini mit wenigen tief einschneidenden Riefen."

with approach of all eight teeth to shovel-shaped formation (p. 120, figs. 120, 121); a single median ridge on all the upper as well as lower incisors in an adult female chimpanzee (p. 122); an approach to shovel-shaped conformation in all the incisors of an "ideal denture" of the adult gibbon, with traces of two median ridges on each of the upper median teeth (p. 123, figs. 134, 135); faint single to double median ridges on all the incisors in an "ideal denture" of an adult gorilla (p. 124); and prominent single broad median ridge on the right upper median, a double ridge on the left upper median, with single ridges on the rest of the incisors, upper and lower, in an "ideal denture" of an adult orang constructed on the basis of a photograph from several specimens (p. 125).

In 1902, in the same serial (H. 9, p. 296, fig. 50), Otto Walkhoff illustrates the fragmentary Krapina upper jaw, in which the three remaining incisors, besides being shovel-shaped, show each a strong lingual multiapical cusp, while the canine bears a complete vertical median ridge with an oblong depression on each side.

In 1908 the subject of ridging and grooving on teeth is touched upon in several places by Adloff in his "Das Gebiss des Menschen und der Anthropomorphen" (8°, Berlin). His remarks are to the following effect:

(P. 11). *Upper Median Incisors*.<sup>1</sup> "The labial surface shows two shallow longitudinal depressions, which in newly erupted teeth end in two notches in the cutting edge of the teeth." On the lingual surface "there are usually three slight longitudinal furrows which, beginning at the tubercle, proceed to the cutting edge of the tooth."

(P. 12). *Canines*. "On the labial surface a distinct ridge runs from the neck of the tooth to the point, and along this ridge on each side is a shallow depression. On the lingual surface, similarly, a prominent ridge extends from the more or less developed tubercle to

<sup>1</sup>(P. 11). "Die labiale Fläche . . . zeigt zwei seichte Längsvertiefungen, die bei eben durchgebrochenen Zähnen in zwei Einkerbungen der Schneide einmünden." . . . *Lingual Surface*. "Am Tuberculum beginnend, ziehen gewöhnlich drei leichte Längsfurchen zur Schneide des Zahnes" . . .

(P. 12). *Canines*. "Die labiale Fläche ist gewölbt. Vom Zahnhalse zur Spitze verläuft deutlich eine etwas erhöhte Leiste; ihr entlang zu beiden Seiten verlaufen zwei flache längliche Vertiefungen. Ebenso zeigt die linguale Fläche keine Konkavität wie bei den Schneidezähnen, sondern eine Wölbung. Auch hier zieht von dem mehr minder entwickelten Tuberculum eine kräftig hervortretende Leiste zur Spitze. Zu beiden Seiten derselben ist je eine ihr parallele seichte Vertiefung bemerkbar." . . .



the point of the tooth, while on each side of the same is observed a parallel shallow depression."

(P. 13).<sup>1</sup> *Upper Anterior Premolars*. On the labial cusp "a broad ridge that extends from the neck of the tooth to the point of the cusp, is found with a shallow groove on each side of it, so that the cusp is plainly divided into three parts. This division of the labial surface in the anterior premolar is almost always distinctly recognizable, but has mostly completely disappeared in the posterior premolar" . . .

As to the masticatory surfaces of both the anterior and posterior premolars, the author occupies himself mainly with the depressions that can here be observed. And in the case of molars he says nothing about the detailed ridging of the cusps, paying attention essentially to the cones and furrows.

A few other notes concerning the ridging of teeth are found in Paul de Terra's volume on the "Vergleichende Anatomie des menschlichen Gebisses und der Zähne der Vertebraten" (8°, Jena, 1911).

(P. 363). "The *incisors*, after eruption, are trilobate, with longitudinal grooves which correspond to the three lobes and which may be traced up to the middle of the crown." The points of these lobes become gradually worn off; until the cutting edge is even. "The lingual surface is concave and marked by longitudinal furrows" . . .

(P. 364). The labial surface of the *upper median incisors* "is slightly convex and shows two shallow longitudinal furrows."

<sup>1</sup>(P. 13). *Upper Premolars*. "Die oberen Prämolaren besitzen zwei Höcker, einen labialen und einen lingualen. Der labiale ist der höhere und breitere. Vom Zahnhalse verläuft auf der labialen Fläche eine breite Leiste zur Höcker Spitze, zu ihren beiden Seiten zwei flache Furchen, so dass der Wangenhöcker deutlich dreigeteilt ist. Diese Dreiteilung der labialen Fläche ist beim ersten Backzahn fast immer deutlich erkennbar, beim zweiten ist sie meistens gänzlich geschwunden" . . .

"Die Kaufläche des zweiten Prämolaren zeigt ein klein wenig anderes Bild. Von ihrer Mitte aus verlaufen nach den vorderen und hinteren Ecken divergierend je zwei Furchen, die ihrerseits am vorderen und hinteren Zahnrande sich wieder vereinigen, so die Form einer Acht bildend. Dabei können aber die beiden flachen Vertiefungen, die sich auf die labiale Fläche fortsetzen, gleichfalls vorhanden sein. Bisweilen verläuft aber nur zwischen den Höckern eine kleine Längsfurche während Querfurchen vollständig fehlen;" . . .

(P. 363). "Die Schneidezähne . . . nach dem Durchbruch, sind dreilappig, mit Längsfalten, welche den drei Lobi entsprechen und welche sich bis auf die halbe Länge der Krone verfolgen lassen. Diese Lobi nützen sich allmählich derart ab, dass schliesslich die Schneidefläche ganz eben erscheint . . . Die linguale Fläche ist konkav und mit Längsrinnen versehen." . . .

(P. 364). *Upper Median Incisors*. "Die Labialfläche ist leicht konvex und zeigt zwei seichte Längsfurchen."

(P. 369). *Upper Canines*: "The dull median ridge divides the labial surface into two triangular facets" . . . .

*Lingual Surface*: "The median ridge, which is also present here, forms together with the well-developed marginal ridges the boundaries of the triangular depressions, which through wear become gradually shallowed until they wholly disappear."

There is nothing on the upper premolars or molars, and for the rest of the teeth de Terra follows Zuckerkandl.

Still another author of prominence who has recently dealt in part with the ridging and grooving of human teeth, is L. Bolk, of Amsterdam. In his elaborate and involved "Morphogenie der Primaten-zähne" (8°, Jena, 1914), he touches repeatedly on the subject of the detailed modelling of the crowns and cusps, both in text and in illustrations, but the separate ridges and grooves are not taken up specifically, and nothing is added to our previous knowledge concerning them. The author, in common with a large majority of odontologists, has concentrated his attention on the cusps and crowns as such and on the subdividing fissures, rather than on the seemingly secondary ridges and depressions.

Among the most recent American authors, Osborn and Scott have for the time being evidently ceased detailed work in odontology; Gregory's excellent work is as yet unfinished; while Wortman, Gidley and Hellman are now devoting their attention to collateral subjects of importance.

#### NEW OBSERVATIONS

The writer's observations on the finer modeling of teeth followed naturally and almost inevitably upon the studies of "shovel-shaped" incisors.<sup>1</sup>

It was seen that in numerous cases, and that both in man and lower mammals, the lingual surface of the incisors, whether shovel-shaped or not, was marked and at times radically modified by a vertical median ridge. Occasionally the human median upper incisors

(P. 369). *Upper Canines*. "Durch die stumpfe Längsleiste wird die Labiale Fläche in zwei dreiseitige Felder geteilt, ein mesiales schmäleres und ein distales breiteres." . . . .

*Lingual Surface*. "Die auch hier vorhandene Mitteleiste begrenzt zusammen mit den gut entwickelten Randleisten zwei flache dreiseitige Gruben, welche durch die Abnutzung sich allmählich verflachen, um schliesslich ganz zu verschwinden" . . . .

<sup>1</sup>Vol. III., No. 4, *Am. J. Phys. Anthropology*.

showed two and even more smaller ridges on the lingual surface; and some more or less plain ridging and grooving was also observed in cases on the labial surface of the teeth. These ridges, both lingual and labial, were soon noticed to be quite independent of both the keilo- and koilomorphy (rim and fossa formation) of the teeth; though the lingual fossa when it existed was now and then observed to be affected by the median ridge, which obscured it more or less and at times, when strongly developed, converted it into two inconspicuous lateral depressions.

It was next observed that these conditions were in substance very much like those occurring on the more posterior teeth, the canines, premolars, and even the molars. In human teeth, lingually or on the masticatory surfaces of the cusps, the same fundamental pattern seemed to appear everywhere where the parts were better developed. This led ultimately to a detailed study of the conditions; and to avoid all extraneous influence literature was not consulted until after the completion of the studies.

The observations were carried out in the main on the extensive human as well as comparative osteological material in the U. S. National Museum. They were very much interfered with by the exceedingly common partial to complete wear of the enamel and consequent obliteration of the finer modeling; but there were also found numerous specimens that gave valuable evidence or indications. The best series of teeth was obtained by carefully breaking up fragments of jaws of Indian children of which a large number was on hand for just some such need. They gave perfect teeth in all stages of immature condition, which alone made it possible in a number of important respects to arrive at some definite conclusions.

The results of the observations are briefly given below. The whole study has convinced the author that there exists a fundamental homogeneity in tooth formation, modified only by functional adaptations, and by degree and perfection of the development of the crowns and individual cusps. Furthermore, these studies do not bear out any of the hitherto advanced theories of tooth morphogeny,<sup>1</sup> but point in another and that quite distinct direction.

The ridges and depressions on the crowns and also on the cusps

<sup>1</sup>Enumerated in H. F. Osborn's admirable "Evolution of Mammalian Molar Teeth," 8°, N. Y., 1907; in L. Bolk's "Morphogenie der Primatenzähne," 8°, Jena, 1914; and in Gregory's most recent publications in Odontology.



of the teeth are fixed, not incidental characteristics. They vary in detail, but recur typically and in the same locations. They are fundamentally alike in the teeth of man, in those of primates and in those of lower mammals. And they appear not only on the incisors, but also on the canines, premolars and molars.

After sufficiently extensive and repeated observations it is seen that, in fact, there is one and the same inherent ridge type for all the teeth from the incisors to the molars, and in all the mammals; but that this type is not developed with equal precision in the different teeth or the different species. The several ridges constituting the type do not have equal potentiality. Some are what might be termed generally prepotent, and therefore in general better developed and more common; while others of weaker potentiality are frequently absent, or deformed, or reduced to mere fragments or vestiges, particularly in certain teeth and certain species. The "potency" of the ridges appears generally to be proportionate to the functional importance of the parts of the teeth to which they appertain.

This ridged condition of the crowns and cusps is so generalized that it compels the assumption of its constituting another of the fundamental characters of the teeth. The ridges according to all indications are homologous formations wherever they occur. They are liable to more irregularity as we proceed from the canines backward. On the molars and particularly the wisdom teeth they are liable to much distortion and rudimentation. In other mammalian forms they may be so distorted or modified as to be wholly unrecognizable. They may be accompanied and quite obscured by accessory wrinkles of the enamel. Yet every now and then in widely different species their presence becomes plainly manifest, or at least may be discerned.

All the above speaks for the morphological importance of these formations. Moreover there is evidence that they or some of them are intimately connected with keilodonty or the rim and fossa formation; and that they have a considerable phylogenetic significance.

#### DESCRIPTIVE NOTES

The ridges and their corresponding depressions are divisible into those of the labial and those of the lingual or masticatory surface of the teeth.

The *labial* ridges with parallel depressions or grooves may best

be studied on the upper median incisors, but occasionally and in a more or less imperfect form become manifest also on other incisors, on the canines and on the premolars. To the trained eye and under a good magnifying glass traces of them will be visible on many teeth where they otherwise might pass unnoticed; but they are usually absent, or present only in vestiges, on the molars.

The *lingual* (or masticatory) ridges and depressions, are on the whole more conspicuous than the labial, except in some incisors. They may be plainly seen on a large proportion of the canines; they may generally be discerned on the buccal cusp of the premolars, and occasionally, in traces, also on the lingual cusp of these teeth; and they are seen on the human and most closely related teeth on the principal, and in rare instances even on the secondary, cusps of the molars.

#### THE LABIAL RIDGES

##### PLATE I

The labial ridges and depressions are more simple and uniform than the lingual, though they are not without variation. In their typical form on a median upper incisor the total labial surface of the crown will be seen to be marked by three well defined, rather broad, longitudinal elevations, one central and two marginal, with two intervening grooves or depressions. In unworn teeth the ridges are seen to reach the edge of the tooth and end there in three tubercles, while the grooves end in the depressions between these tubercles, the whole giving a serrated type to the edge of the tooth. In especially marked cases the central and lateral welts will be such as to divide the crown into three nearly equal parallel or somewhat diverging columns or lobes—this especially in the median incisors. In the lateral incisors the central lobe is liable to be the stoutest and its terminal point to project beyond that of the lateral lobes, particularly that on the distal edge of the tooth. In some primate incisors, and especially in the incisors of the carnivora, we find that the three “lobes” in question correspond to three more or less distinct cones, and it thus becomes plain that the three labial ridges which we observe occasionally in man, some anthropoid apes and some other mammals, correspond to the cone areas of the triconodont type or phase of the tooth, while the two depressions between the ridges are homologous with the cone separations. The gap between a typical triconodont and a typical



PLATE I. UPPER LEFT FIGURE: Permanent front teeth of a German boy; showing labial ridging. (After Zuckerkandl). —UPPER RIGHT: Permanent upper median incisor of (a) an Orang (142,196, U. S. N. M.); (b) a Water Buffalo of Celebes (219,763, U. S. N. M.) and (c) American Indian (loose teeth, U. S. N. M.), showing identical type of labial ridging. —MIDDLE LEFT: Skull of a Sioux child (243,362, U. S. N. M.) with a complete single median ridge on each of the deciduous median upper incisors. A partial median ridge on left lateral incisor. —MIDDLE RIGHT: Orang (144,691, U. S. N. M.), showing deciduous lower incisors with a well developed rim, lingual concavity and pronounced median ridge. —LOWER: Orang (153,821, U. S. N. M.), with permanent lower teeth showing a tricuspid edge (median and partly also lateral incisors, and a marked single median ridge (lateral incisors and canines).





PLATE II. Upper Row: Immature Median Incisors, the two on left Old Egyptian (XII Dyn.); on right, Indian.  
Lower Row: Immature Indian Canines.

Nos. 1 and 2 above show three lingual ridges each besides the two marginal ones; the third shows two ridges (besides the marginal), the right and median, while the fourth shows the left and the median lingual ridge. The canines below show each the two marginal ridges, a pronounced median ridge and fragments of the lateral ridges, particularly the left.

labially tri-lobed incisor with a sufficient number of specimens at our command could probably be filled without interruption, and the correspondences here mentioned be actually demonstrated. As we pass to the more posterior teeth however, the matter becomes progressively more difficult.

The variations in man of the tri-ridge and bi-groove pattern of the labial surface of the incisor, and occasionally of the canine and even a premolar, consist most frequently in diminished clearness of these structures; in a preponderate rôle assumed by either the median or the lateral ridges, in the first instance the surface appearing but single ridged, while in the other much rarer cases and limited to incisors, the labial surface of the tooth with the lateral welts well developed and the median inconspicuous to absent, comes to resemble considerably the rim-and-fossa condition of the lingual surface; and it in fact is more than a resemblance.

The indications of the features under consideration on the canines and even on the premolars and molars, however rare and imperfect they may be, can signify of course but one fact—a fundamental identity of organization or histogeny of these teeth with that of the incisors.

#### LINGUAL RIDGES

##### PLATES I, II, III, IV

The occurrence of enamel ridges on the lingual surface of the teeth is more frequent and in general much more conspicuous than that of those on the labial surface. Moreover they are found on all the teeth, though on the molars they are practically restricted to the cusps and are "masticatory" rather than "lingual."

The fundamental lingual ridge pattern of the human teeth is that of a median, two lateral and two marginal ridges—hence five ridges in all with three intervening depressions. The median ridge is straight and vertical; the laterals may be straight or slightly curved, and proceed distad in a more or less divergent way from the median ridge; the two marginal (or rim) ridges are as a rule somewhat curved, and follow the margin of the teeth. It is the two lateral inside ridges which are the least stable and regular, while the median and the marginal ridges appear to possess about the same potentiality. Of the lateral ridges one or the other may be completely absent, with the other slightly to well developed, in which case the result will be two

lingual ridges, such as are seen occasionally on the upper median incisors. These particular ridges may be of a double, coronal and accessory, origin. They develop with the crown, and can be found before the cingulum joins the latter; but they may subsequently be strengthened or even represented by an extension of two points from the cingulum or tuberosity. When both the lateral ridges are absent, we obtain the single median ridge type which is the most common of all the variations of the ridging. When the marginal as well as the lateral ridges are wanting and the median exists, we have a form such as seen frequently in the canines. When the lateral as well as the median ridges are absent and the marginal exist, we have the keilokoilodont or shovel-shaped form, which is so frequent in certain human and ape upper incisors. Finally, when all the lingual ridges are absent we obtain the smooth surface such as is found in many incisors of the modern white man.

The manifestation of these lingual ridges differs in its tendencies in the different teeth.

The median ridge occurs occasionally on the median upper incisor; more frequently on the lateral upper incisors; in some instances on the lower incisors (both deciduous and permanent); generally on the canines; as a rule on the outer cusp of the bicuspid; with varying frequency, according to the individual teeth, on the inner cusp of these teeth; and almost invariably on the three older cusps of the molars, but occasionally also appearing on the fourth and fifth cusps. No cusp whatever is devoid of the possibility of developing the median ridge, but as a rule only the larger better developed cusps will show the feature. Not infrequently the median ridge is obscured in the median convexity of a cusp or a tooth. Where better discernible it generally extends from the base to the point of the crown or cusp of the tooth. And it may be so developed as to take up a larger part of the inner or lingual surface of the cusp or tooth. It can be plainly traced in the teeth, even in the canines, of the anthropoid and other apes, and in many of the teeth of the lower mammals. It is the central ridge of the median main "lobe" of the tooth, or the "protoconid," and of the corresponding portion of each cusp.

This ridge possesses a considerable significance. Its homology on the various teeth and on the cusps in the molars cannot be questioned. Its function on all is evidently to strengthen the tooth or cusp, and it corresponds to the median external ridge, a well defined presence of





PLATE III. Skull of a prehistoric or early historic Peruvian Indian (293,114, U. S. N. M.); median shovel-shaped incisors show each 2 heel cuspules; right lateral, a partial median ridge; both laterals a marked complete rim and pronounced fossa; both canines a distinct rim, a median ridge and heel cusp.



PLATE IV. Immature Indian Upper Premolars and Molars, showing ridging. Two of the premolars show clearly the five ridges, the median, two laterals and two marginals. On the molars the cusps show the median and marginal ridges. (Enlarged)

which however is less frequent. Its presence on the cusps of the molars, even occasionally on the latest additions, the fourth and fifth cusps, is a remarkable condition. These cusps are not "lobed;" they are not "triconodont;" for if they were each cusp of the molars would have the value and significance of an individual, primitive, ancestral tooth. But the presence of the median ridge, homologous with that of the premolars, canines and incisors, suggests that the cusps of the molars are following in the line of standard development of all the teeth; and that if conceivably their evolution could progress in the same direction, each cusp would develop the tri-lobed or triconodont character of each of their more anterior separate teeth. If this can be substantiated it must naturally have a far reaching influence upon our whole view of tooth development and evolution. The real ancestral feature would then be, not the Cope-Osborn triconodont tooth, but a general inherent tendency towards a triconodont formation.

The lateral or intermediary lingual ridges, are the median strengthening ridges of the lateral "lobes" of the teeth. They are best developed, on the whole, on the outer cusps of the upper premolars. Occasionally they may be clearly represented also on the median incisors. They are occasionally perceptible in a fragmentary form on the canines; and traces of them seem to be distinguishable occasionally on a cusp of a molar, but their identity here is as yet uncertain. In conformity with the lesser development of most of the lateral lobes and cones, these ridges are also less conspicuous and are frequently reduced to mere vestiges or are absent altogether. Their morphological significance goes only so far that they show over the lateral ridges or cones of the teeth the same mechanism as exists for the strengthening of the important central lobe. Nothing exactly corresponding to these ridges is observable on the labial or dorsal surface of the teeth, though the lateral ridges occasionally seen there bear some relation.

What in the above respects applies to man may be said also of the chimpanzee, gorilla and orang, though the conditions show more or less aberrance. This is particularly true of the canines of these species, yet the median lingual ridge, once well known, can readily be distinguished even on these far specialized "brutalized" teeth. In the lower incisors of these apes the median ridge assumes much more importance than it does in these teeth in man, in whom in fact it is here rarely noticeable. Furthermore the marked development of the



median ridge in the anthropoid lower incisors extends to both the deciduous as well as the permanent set.

In the lower apes, excepting a few of the largest forms, conditions in these respects are considerably simplified and it is impossible to distinguish clearly more than the single median ridge, which however exists on most of the teeth and cusps.

In the Carnivora the single median lingual ridge is noticeable to pronounced on the incisors and pre-canines, may be traced on the canines, and is again discernible to well marked on the premolars and molars. In the Ungulates the single median ridge is slightly to exceedingly well marked on the lower incisors (the only incisors present), and may be traced on the lingual aspect of the premolars and molars. It assumes great strength and prominence on the lower incisors of some of the Suidae. The median ridge may also be perceived on some of the teeth of the rodents and marsupials. It is its presence which justifies the viewing of all mammalian teeth as essentially lophodont and lophoconid.

What is the significance of all these ridges? It will be impossible to say a final word on this point without further comprehensive studies including those of an embryological and palaeontological character. Nevertheless the examination of such extensive material as that at the disposal of the author permits of some tentative conclusions.

These are briefly as follows:

(1) The crowns and cusps of the human and other mammalian teeth show in general an inherent tendency to ridging, or to *lophodonty* and *lophoconidy*.

(2) The functional role of the ridging is to strengthen the teeth and cusps and to assist trituration of food.

(3) There is but one fundamental pattern of ridging of both the crowns and the cusps in the whole mammalian kingdom; which pattern however is subject to a wide range of modifications.

(4) The ridging is partly marginal (keilodonty) but in the main intermarginal (lophodonty, lophoconidy); and the latter is directly connected with an equally inherent and old triconodont tendency of the teeth and cusps.

(5) The intermarginal ridges are the axial ridges of the more or less differentiated "lobes" or "cones" of a tooth, the lobes or cones



PLATE V. TRICUSPID PREMOLARS

LEFT. Bannock Indian, Male, (243,837, U. S. N. M.). Left anterior upper premolar clearly tricuspid.  
 RIGHT. *Hyllobates* sp., Sumatra, Male (123,151, U. S. N. M.); left posterior upper premolar clearly tricuspid.  
 (Actual size of parts seen, Fig. 1, length, 7.3 cm.; Fig. 2, 4.3 cm.)



PLATE VI. UPPER: Mandible of a Male Gorilla (176,211, U. S. N. M.), showing molariform posterior premolars. The right premolar shows three distinct small accessory cusps which if enlarged would reproduce the three posterior cusps of the first molar. (Natural size).

LOWER: Lingual, right lateral and mid-section views of an immature Indian upper median incisor (Div. of Phys. Anthropol., U. S. N. M.), showing a peculiar, nearly circular, developmental fissure in the enamel at about the upper boundary of the cingulum, with traces of another fissure below. The section shows faintly a small accessory root projecting downward from the dentine. (Actual length of tooth=13 mm.)



that in extreme cases would give the typical triconodont tooth, or a triconed cusp.

(6) The differences of the ridging in the crowns of the incisors or canines and the cusps of the premolars or molars, are merely those of degree.

(7) The médian of the intermarginal ridges of a crown or a cusp is without exception the best developed and most frequent. It is the axial ridge of the "protocone" or "main lobe," and the main strengthening ridge of the crown or a cusp as a whole.

(8) The depressions lateral to the intermarginal ridges are remnants of keilomorphous feature of the surface, a separate condition.

(9) Phylogenetically, lophodonty and lophoconidy do not appear to be either remnants of or reversions to any primitive ancestral condition of teeth or cusps, but an inherent morphological tendency of progressive possibilities.

(10) Finally, the results of the study of these ridges together with that of the cingulum and the cusps, indicate the entire homology of the various teeth; the homomorphy of the crowns and the cusps; and the origin of the various teeth not by differentiation of a primitive triconodont type (Cope, Osborn), or by accretion of primitive teeth (Kükenthal, Röse, etc.), or from an original bicuspid, or "dimere" form (Eterode, Bolk), but from monomere crowns with the cingulum, by the development, under functional call, from the cingulum, of additional cusps, with similar morphogenic endowments or possibilities as those of the older crown or cusp, and which gradually assume a stabilization and similar form with the older constituents of the tooth.

## THE CINGULUM. THE CROWN "SUTURE"

### PLATES V, VI

The cingulum has long been a sort of a "will-o'-the-wisp" of dental anatomy. Everyone speaks of it, and many have more or less casually attempted to define it,<sup>1</sup> but no one has as yet dared to tell us conclusively just what it is, what are its boundaries, the reasons for its being, and its potentialities.

To the zoologists and the paleontologists, the cingulum is of even greater concern than to the student of human teeth. They understand by it the enamel swelling or belt that surrounds or embraces

<sup>1</sup>See first section of this communication, *A. J. P. A.*, 1920, III., 429 et seq.

the crown of the tooth near its base, and from which at times are seen arising accessory cusps of the teeth; but they, in common with human anatomists, do not clearly distinguish between features that may and may not be attributed to cingulum origin.

In his study of immature human teeth, the writer observed a number of conditions which have more or less bearing on these points. And in the first place it was seen how easily it would be possible for one to be misled by appearances assisted as they may be by the views of respected authors.<sup>1</sup> A number of the Indian incisors and other teeth under examination showed on the developing crown a peculiar cross "suture" of which no mention could be found in the available dental literature, and which gave the impression as if it might possibly mark the junction line of the cingulum with the rest of the crown. In one case especially, that of an upper permanent median incisor (Plate VI) it seemed as if we had a plain separation of the cingulum. But further studies weakened whatever confidence there may have been placed at first in these manifestations, and finally took away all hope that anything like a separate development of the cingulum could be established.

What was observed on the dry material (mostly of prehistoric Indian origin), was briefly as follows:

<sup>1</sup>A separate development of this basal portion of the enamel was believed in specially by Black (Descriptive Anatomy of the Human Teeth, Black (G. V.), Phila., 1st ed., abt. 1889; quoted after 4th ed., 1897; same in 3rd ed., 1894). He calls it the *linguo-gingival ridge*, and his views on the part are as follows:

"The lingual surface of the crown [of the upper incisors] (Fig. 2), is concave in all directions forming a *fossa*, bounded by the cutting edge, the mesial and distal marginal ridges, and the *linguo-gingival ridge* or cingulum. . . . The *linguo-gingival ridge* is a strong elevation of the enamel forming the *linguo-gingival border* of the crown. It is sometimes elevated into a tubercle . . . . The calcification of the *linguo-gingival ridge* or cingulum, is also begun as a separate plate, forming the *lingual lobe*, but afterwards it becomes united to the other parts by confluence, leaving a groove, often very slight indeed, and soon obliterated by wear, marking the line of union. This is the *linguo-gingival groove*. (This groove is properly three grooves corresponding with the mesial, central and distal grooves of the bicuspid, while the *linguo-gingival ridge* corresponds to the lingual cusp). In smooth regularly formed teeth it begins at the gingival line just lingual of the summit of its labio-lingual curvature, and runs across the marginal ridge at right angles with its length, then runs almost horizontally across the lingual surface to the distal marginal ridge. This ridge is now crossed at right angles, and the gingival line reached. The length of the groove usually includes from a quarter to a third of the circumference of the tooth. When the *linguo-gingival ridge* is prominent or rises in the form of a tubercle, this groove is subject to much variation in its course. Occasionally, especially in the lateral incisors, a sulcus, or a fissure divides the *linguo-gingival ridge* from one of the marginal ridges, and extends into the cementum. This is the *linguo-gingival fissure*."

*Crown Development. The Cingulum.* The crowns as a rule were seen to commence to develop with what was or were to be their most distal points, and what were probably the oldest points phylogenetically. At various times during earlier childhood it is possible to find in the alveoli the tips of the cusps of the molars, premolars and canines, the cutting edge portion in the incisors. The enamel development appears to dominate over that of the dentine which on the inside forms its thin and morphologically probably passive lining.

As the growth proceeds, the crown and cusps manifest gradually all the main features which they are to bear in the fully developed teeth. Thus there appear—in teeth where they are to exist—from an early stage the marginal, median, secondary and labial ridges with their corresponding concavities. All this well before the appearance of "cingulum" or the root.

Next, in the molars, the cusps coalesce and the growth of the crown proceeds uniformly until the enamel reaches its basal limits; but before it has reached these and before the dentine lining begins to protrude to form the roots, the enamel already shows a perceptible basal swelling—the cingulum. Microscopically there has been no separate brace, no accessory enamel body. The cingulum formation appears to be inherent in and constitute an inseparable part of process of the development of the enamel portion of the crown of each molar.

The premolars follow practically the same course of development as the molars. The tip of the labial cusp appears first, then that of the lingual; the two then join, and the enamel grows uniformly in the direction of the eventual root. The basal swelling of the enamel, or cingulum, appears in the last stages of the development of the enamel portion of the tooth.

In the canines and incisors the process of development is the same as in the more posterior teeth, except that there is but a single cusp or edge. The occasional secondary additional cusp, when to be formed, develops subsequently from the heel or tuberosity, which in these teeth seems to be the only "potential" part of the cingulum.

According to these observations, which in the course of time will doubtless receive more precision, the cingulum is a regular and inseparable part of the epithelial or enamel development of each tooth. It is something not superadded, but inherent in the crown. It exists for special purposes. What these purposes are, is plain enough: They



are in the first place to strengthen the crown; and in the second to provide in response to functional call for the possibility of additional cusping and hence for an increase in the effectiveness of a tooth.

In the incisors the cingulum develops the lingual heel; from this heel it sends out to the crown one or two strengthening ridges; the point of the heel differentiates occasionally into one or more points, a cuspule, or even a definite cusp which may reach as far as the cutting edge of the crown and convert the tooth into a bicuspid. In the canines is formed a lingual heel, which often gives rise to a cuspule. In the premolars, the original lingual cingulum cusp has already become a fixed feature; but occasionally—in the gorilla, other anthropoid apes and even man—the remaining cingulum of the premolars begins mesially (posteriorly) to respond to functional need with a third, and even a fourth cusp (anthropoids). The molars, too, have apparently but one protocusp, with two to three already fixed cingulum cusps, and a remaining cingulum capable of producing still other cusps or tubercles.

In view of the preceding, the cingulum may perhaps be defined as the basal, inherent, inseparable, but histogenetically the most potential, part of each tooth crown.

#### THE CROWN "SUTURE"

Examination under a magnifying glass of a large number of immature, permanent Indian teeth, incisors, canines, premolars and molars, showed in over half of the cases that the crown of the tooth was crossed labially, and sometimes all around, by a peculiar serrated or interdigitate line which could not be identified with anything hitherto described in the dental literature that was at the writer's disposal, and which under low magnifying power resembled not a little some forms of sutures.

As already mentioned, the first few examples of this "suture" were in such a situation as to suggest that they might indicate a possible superior limit of the cingulum, which if that were true would have to be regarded as an accessory part of each tooth. Subsequently however the "suture" was found in crowns that have reached nowhere near the usual location of the cingulum, and it was recognized that we were confronted here with quite a different manifestation.

Just what this feature is, is as yet not clear. It is something quite different from the so-called "Schreger's" lines. It is not only present

on all forms of teeth, but occasionally shows even a better development on the canines, premolars and molars than on the incisors. Near one-half of the immature Indian teeth show no trace of it. The crowns that do show it, so far as observed, are from about one-third to nearly fully developed, and as far as can be seen fully normal.

As to location, the "suture" runs in most cases 1 to 3 mm. above the lower border of the crown; but it runs higher than this not infrequently. In one about half or a little more developed upper median incisor crown, it runs across the middle and slightly above the middle of the part already developed; while in another about two-thirds developed crown of a lateral upper incisor, it runs even higher, namely from near the cutting edge on the left to a point between the distal and middle thirds of the part that has already been formed on the right side of the labial surface of the crown. In the premolars and molars, the "suture" may run partly over the less important cusps.

#### CROWN "SUTURE"



FIGURE 2. Crown "Suture" in various immature American Indian teeth. (U. S. National Museum.)

- a. Lateral incisor, crown about  $\frac{3}{4}$  developed, showing a very high location of the "suture."
- b. Half developed crown of an upper median incisor, with "suture" in about the middle.
- c. A fully (or nearly fully) developed crown of an upper median incisor with "suture" low down.
- d. Crown of a canine, about  $\frac{2}{3}$  (or a little over) developed with a relatively simple "suture."
- e. Crown of an upper premolar, about  $\frac{2}{3}$  developed, "suture" rather high, oblique.

Under low magnifying power the "suture" appears consisting of a belt-like complex of numerous angular more or less vertical lines which here and there connect, the connecting lines being partly curved and partly straight. Under stronger enlargement it is seen that the lines are so many crevices in the enamel, which separate deeply but often more or less incompletely numerous irregular enamel blocks. The "suture" is therefore, properly, a more or less broad and complex ring of defects of cementation.

Just what all this represents must be left to future determination. The crown "sutures," though probably accentuated somewhat by the

dryness of old specimens, are plainly no mere lines of accidental cracks nor any other artifacts. They do not extend to the dentine, but involve the enamel only. They may "furrow" a whole cusp. They bear no sign of being connected with anything pathological. They progress from the distal towards the proximal parts of the crown, as the crown grows. Their remnants in fully developed crowns may possibly be the "Schreger's lines." They evidently have some definite and perhaps regular connection with the development of the enamel surface of the crown, and could possibly be conceived as more or less circular areas or lines of demarcation between the older fully differentiated and the younger parts of the crown, or as areas or lines of secondary cementation in the enamel; but for the present no valid opinion can be given.

The same feature but in somewhat modified forms was since seen in the Division of Mammals of the U. S. National Museum, in an immature molar of a leopard, in a very young crown of a molar of a chimpanzee (No. 176,233), and in the immature upper incisors and premolars of a baboon (162,845).

#### ADDITIONAL OBSERVATIONS ON HUMAN INCISORS

##### LINGUAL CUSPS

##### PLATES III, V

A lingual cusp may be defined as a more or less marked, single, double or multiple protuberance from the heel of an incisor or a canine. The lingual heel is, as shown before, the essential part of the cingulum of these teeth.

In mature human teeth the heel and the lingual cusps are variously represented. The heel may be seemingly absent, inconspicuous, or replaced by an extension or fusion of the marginal crests; or it may rise to a moderate convexity or be developed into a strong tuberosity. It may often be seen to be separated on one or even both sides from the lateral border or borders of the tooth by a shallow to marked groove, and in the lateral upper incisor the portion of the root which supports the heel may show a vertical furrow, indicating a prospective separation into two roots. From the heel may rise one or two more or less elevated ridges which are prolonged to and taper out on the lingual surface of the tooth; or instead of ridges there project from the heel one, two or even more buds or points, the lingual accessory



cusps. A single strong lingual cusp may in extreme cases, in an incisor, reach near or to the cutting edge of the tooth and give the same a form approaching that of a bicuspid.

The lingual cusps occur most frequently and as a rule singly on the canines; singly and less frequently, rarely doubly, on the lateral upper incisors; singly and very rarely on the lower incisors; and doubly, singly, or in several points on the upper median incisors. They are found in teeth that are shovel-shaped as well as in teeth that are flat, and they seem to occur in all living races of man, but in a human-like form have not as yet been signalled in any of the primates or lower mammals, though the heel or tuberosity in many of these is well developed and may show an edge-like excrescence.

These accessory cusps have long been known in dental literature, but their exact frequency and racial distribution have never been determined. Such determinations moreover are not easy, the difficulty lying in what to and what not to include under the term "cusp," particularly in the case of the median incisors. As a result, probably no two observers would reach precisely the same results on the same series of specimens; but the differences would in all probability not be serious enough to obscure the main facts.

The writer has used the same material in the study of these cusps as that in the study of the shovel-shaped formation, with the results shown in the table below. Only those features were included as "cusps" which could be readily discerned as such. As the results indicate, such cusps are present in approximately 5 per cent of all the cases, with a slight excess showing in the males over the females, and in the colored (particularly females) over the whites. In a large majority of the cases the cusp was single, but in a certain proportion of individuals, particularly among the colored, the median and even the lateral incisors showed two small cusps. More than two cusps were not observed in any case of any group. The double cusp was generally more of the nature of a marked double elevation, rising from the heel and gradually losing itself on the lingual surface of the teeth. But no simple ridges, though homologous, were included in this category, and in some of the cases the cusps were more or less free from the enamel behind. In rare instances the secondary cusp, while not free, reached to near the cutting edge of the incisor, forming a tooth resembling more or less a bicuspid.

The writer's impression is that these cusps are functional acces-

sories; and that they are not more frequent among the yellow-brown peoples than among the whites; but both points deserve further investigation. Data on Indian teeth appended to the table, indicate conditions but little different from those in the whites and American negroes.

#### CUSPS IN DECIDUOUS HUMAN TEETH

The skeletal material of Indian children in the U. S. National Museum enabled the writer to examine 41 deciduous upper median and 39 deciduous upper lateral incisors in good condition. Of these, two medians (near 5 per cent) and two laterals (slightly over 5 per cent) showed a distinct small basal cusp. In addition twelve of the medians and ten of the laterals presented a "swollen" heel or tuberosity, a condition seemingly on the verge of a cusp formation.

#### LINGUAL CUSPS.

	On all Permanent Incisors		Both Medians		Both Laterals		Right Lateral Only		Left Lateral Only		Anomalous	Teeth with Cusps	
	1 cusp.	2 cus.	1 cusp.	2 cus.	1 cusp.	2 cus.	1 cusp.	2 cus.	1 cusp.	2 cus.		No.	Pct.
WHITE MALES (500)	Individuals: 6 Pct. of 1.2	2 Indiv. 0.4	5 1.0	5 1.0	25 5.0	.....	6 1.2	.....	3 0.6	.....	.....	111 (of 2000 inc's)	5.6
WHITE FEMALES (500)	2 0.4	.....	1 0.2	4 0.8	28 5.6	.....	3 0.6	.....	2 0.4	3 0.6	.....	81	4.05
COLORED MALES (307)	4 1.3	2 0.6	1 0.3	4 1.3	12 3.9	.....	6 2.0	.....	2 0.6	3 1.0	3 1.0	72 (of 1228 teeth)	5.8
COLORED FEMALES (500)	.....	5 1.0	5 1.0	4 1.8	28 5.6	1 0.2	5 1.0	.....	4 0.8	.....	0.2	106	5.3
AMERICAN INDIANS 302 medians 353 laterals	Teeth Per cent		Medians, r. o. r. l. 5 1.6	5 1.6	Late rals, r. o. r. l. 27 7.6							37	5.6

#### DEGENERATE AND ABSENT INCISORS

The lateral incisor, as well known, presents not infrequently a more or less degenerate form with reduction in size. It may be represented by a mere peg, and may be absent altogether. Records of these conditions were taken in all the groups examined by the writer, and the results, summarized in the accompanying tables, are rather interesting.

No case was seen of a degenerate median incisor, and in only one instance was one of these teeth congenitally absent—possibly impacted.

## UPPER INCISORS DEGENERATE

## MALES

## FEMALES

Living Subjects	Both Laterals Involved	Right Lateral	Left Lateral	Total		Both Laterals	Right Lateral	Left Lateral	Total
WHITES (500)	Individuals (10) Percent: 2.0	(4) 0.8	(3) 0.6	(17) 3.4	WHITES (500)	(6) 1.2	(3) 0.6	(5) 1.0	(14) 2.8
AMERICAN NEGRO (307)	(6) 2.0	(1) 0.3	(1) 0.3	(8) 2.6	AMERICAN NEGRO (500)	(14) 2.8	(6) 1.2	(2) 0.4	(22) 4.4
HAWAIIAN (21)	(1) 5.0	...	...	(1) 5.0	HAWAIIAN (38)	...	...	...	...
CHINESE (547)	(31) 5.7	(5) 0.9	(10) 1.8	(46) 8.4	CHINESE (104)	(2) 2.-	...	(2) 2.-	(4) 4.-
JAPANESE (172)	(5) 2.9	(2) 1.2	(1) 0.6	(8) 4.7					

## CONGENITAL ABSENCE OF LATERAL UPPER INCISORS

## MALES

## FEMALES

Living Subjects	Medians	Both Laterals Absent	Right Lateral	Left Lateral	Totals		Medians	Both Laterals	Right Lateral	Left Lateral	Totals
WHITES (500)	Individuals: 1(r.m.) Pct. 0.2	(3) 0.6	(1) 0.2	(2) 0.4	(7) 1.4	WHITES (500)	...	(6) 1.2	(5) 1.0	(4) 0.8	(15) 3.0
AMERICAN NEGRO (307)	...	2 0.6	2 0.6	1 0.3	(5) 1.6	AMERICAN NEGRO (500)	...	(3) 0.6	(4) 0.8	(2) 0.4	(9) 1.8
HAWAIIAN (21)	...	...	...	...	...	HAWAIIAN (38)	...	(1) 2.6	...	...	(1) 2.6
CHINESE (547)	...	...	...	(1) 0.2	(1) 0.2	CHINESE (104)	...	...	...	...	...
JAPANESE (172)	...	1 0.6	1 0.6	...	(2) 1.2						

The total number of individuals showing degenerate upper lateral incisors amounted, among the American Whites, to a little over 3 per cent of the males, and a little below 3 per cent in the females. In the Negro, the proportion was below 3 per cent in the males to above 4 per cent in the females, but the females included more of the "lighter colored" in whom the condition appears to be more frequent than in the "darker" subjects and full-bloods. In the Chinese, the proportion of degenerate upper lateral incisors is more than twice as frequent as



in the Whites in the males, and also perceptibly more frequent in the females; and there is also a higher proportion of the condition present in the Japanese.

As to congenitally absent upper lateral incisors, a condition the reverse of that found with the degenerate teeth is observable (except in the Chinese group)—they are more common in the females than in the males. Also their absence is slightly more common in the American Whites than in the Negroes, and somewhat more common in both of these than in the Chinese and Japanese. It is evident therefore that the statistical study of both degenerate and congenitally absent lateral incisors in the different races deserves further investigation.

Both the degenerate condition and the absence of the lateral incisors have been noted by many Odontologists; but the data for various reasons are not readily comparable. About the best series has been reported by Röse.<sup>1</sup> Among 12,250 living northern and central Europeans (soldiers and recruits in Germany and Sweden), degenerate or absent lateral incisors, taken together, were noted in 3.2% of the men; while in 2811 crania (of, in the main, colored races), the proportion of degenerate or absent lateral upper incisors was but 1.1%. Röse's conclusions with which in the main it is possible to agree, were that:

"The degeneration of the upper lateral incisors and that of the wisdom teeth rests on phylogenetic causes and not on unfavorable accommodation in pathologically changed maxillae.

In the higher standing European races with larger brains the degeneration of the lateral upper incisors and that of the wisdom teeth is in general farther advanced than in non-European races.

In the nordic longheads the lateral upper incisors are more often, the wisdom teeth less often reduced than among the shortheads of the Alpine race.

In the females, degeneration of the upper lateral incisors is further advanced than in males."

The subject will well repay a further study on large series of both living and skeletal material.

<sup>1</sup>RÖSE (C.). Über die Rückbildung der seitlichen Schneidezähne im menschlichen Gebisse. D. Monatsschr. f. Zahnheilk., 1906, XXIV, 5.

## EVOLUTION OF MOLAR CUSPS IN MAMMALS

J. L. WORTMAN<sup>1</sup>

The evolution of the molar cusps in the Mammalia, is a broad and complex one, and one, moreover, upon which volumes have already been written without arriving at any generally accepted or well-established final conclusions regarding the matter. While I have not devoted much time to the subject for a number of years past, it is my opinion, however, that the science has been in a condition for many years to indicate or outline some general conclusions in the evolution and morphology of the molar cusps in certain groups of the mammals, at least, that are not very likely to be changed or modified by future discovery, and that may be regarded, therefore, in the light of a certain degree of fixity and finality.

The first of these conclusions to be enumerated, is to the effect that of the forces and factors concerned in the process of molar and premolar cusp addition and modification, those of stress, strain and impact have been in large part instrumental in producing the results accomplished. Such stresses, strains and impacts, have, without much doubt, furnished the causes or stimuli for favorable variations in the tooth crowns, which have been seized upon and perpetuated by selection in such a manner as to register a steady advance in molar and premolar evolution. This doctrine was first enunciated and promulgated by the late Professor John A. Ryder in a notable paper on "The Mechanical Genesis of Tooth Forms," in the Proceedings of the Philadelphia Academy for 1880. He may, therefore, be regarded as the **great pioneer** in this subject in this country. This hypothesis, while not susceptible of final proof, like so many other problems in evolution, is, nevertheless, supported and sustained by such an overwhelming array of evidence, from both the fossil and living Mammalia, as to be little short of axiomatic in its nature. It may, therefore, be accepted, in my judgment, as not far wide of the truth.

<sup>1</sup>This communication, received in December, 1920, was sent to the Editor by Dr. Wortman in answer to a request for a statement as to Dr. Wortman's present views on the subject of the evolution of the cusps in the human and mammalian molars. Ed.

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The next broad conclusion to which we may safely give our adherence, in the matter of molar and premolar evolution, it seems to me, is to the effect that in any given connected group or phylum, whose history we are able to trace over any considerable period of time, and wherein the cheek teeth have undergone progressive modification, those towards the posterior end of the tooth row have been the first to be affected by these changes, by reason of the fact that they have borne the brunt, and have been subjected to, and have sustained the greatest amount of stress, strain and impact during the comminution and mastication of the food; that this modifying influence has spread from this point forwards along the tooth row, in many instances involving the entire series successively, including each preceding individual tooth along the line, until these anterior teeth have become very similar to, or exact counterparts of the modified teeth behind them, or, in other words they have become molariform; that these anterior complicating tooth crowns furnish us, in a large number of instances, with a safe, reliable and unmistakable guide to the various steps and stages along the route or pathway by which the complication has been gradually brought about in the molars.

This conception of the rise or origin of cusp complication and multiplication in the Mammalia is known as the "Doctrine of Premolar Analogy" or better "Premolar Homology," and was first enunciated by the writer in a series of papers published in the American Journal of Science for 1901-1902 and 1903-1904, on Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum, Part I, Carnivora, and Part II Primates, pp. 93-98 and pp. 214-218, Separata. The evidence or proof of this theory as originally announced by myself, rests primarily upon that furnished by the teeth of the *Dissacus-Pachyaena-Mesonyx* phylum, an extinct group of creodont carnivores, extending in time from the Torrejon or Upper Basal Eocene stage to the Bridger or Upper Eocene. The facts of premolar evolution were first brought out by Scott in a paper published in the Proceedings of the Philadelphia Academy in 1892, in which he demonstrated very fully and conclusively the various steps or stages, as well as the order of cusp addition in the evolution of the molariform premolars of a number of groups of the Mammalia. At that time, however, it was held by Osborn that in the evolution of the molar crowns, these teeth had had an entirely distinct and different history from that of the molariform premolars. In this view Scott evidently acquiesced, since



he failed to grasp the broad and far-reaching significance of the principle embodied in his discoveries of premolar evolution, as applied to the molars, and contented himself with a consideration of the order of addition of the various cusps, without in any way attempting to apply it to the molars. He accordingly proposed a nomenclature for these cusps, based upon their order of appearance or addition to the crown.

As regards the view held by Osborn and his followers in the matter of cusp evolution in the teeth of Mammalia, I cannot do better than to quote here my original criticism of his position, which is to be found in Part II above referred to, at pp. 215-216 *Separata*. This is as follows: "In Part 1 of the present series of papers, I have presented my views at some length upon the theory of "Cusp Migration," as originally propounded by Osborn. I have likewise dissented from the use of the terminology of the mammalian molar cusps proposed by him, on the ground that their homologies were incorrectly determined and the names applied inappropriate and misleading. I have further expressed the opinion that, as far as any nomenclature is applicable to these cusps, which would convey any information of their homological relationship, that proposed by Scott is preferable, because based upon ascertained and undisputed facts in the history of the premolar series. By far the most important principle embodied in Scott's determination of the order of appearance and homological position of the cusps of the premolars, although never expressed nor stated by him, is that by means of which we are provided with a key to a proper interpretation of the molar cusps and the determination of their history. All theoretical considerations, as well as all the evidence obtainable, point with such directness and definite precision to the conclusion that the molars and molariform premolars have passed through identically the same changes and have been subjected to precisely the same influences, that it may be accepted as one of the basic and fundamental truths of dental morphology. Credence in any other view would be equivalent to believing that the corresponding teeth on the opposite sides of the mouth have had different histories, or that each individual molar has had a separate and distinct history in its cusp evolution. This principle or law has not as yet been ocularly demonstrated, except in the case of the *Dassacus-Mesonyx* phylum, for the reason that no Eutherian mammals older than those from the Tertiary are known. In the earliest Eocene, the molars, with a few

notable exceptions, had already assumed such a degree of complexity as practically to obliterate all traces of the order of appearance and manner of development of the various cusps. When, however, the ancestors of the Puerco fauna are found, and the more primitive stages of their tooth development obtained, we may look forward with the utmost confidence to the production of all the evidence necessary to a complete and final demonstration of this hypothesis." I may further add to this criticism made nearly twenty years ago, that I am at this moment unable to recall a single fact or the first vestige or scrap of evidence that has been uncovered during this time that lends any support to Osborn's contention, to the effect that the molars and molariform premolars have reached identical stages of evolution through separate and distinct channels and through different influences.

If this second conclusion or generalization above set forth is true, and is supported and sustained by the facts, as I believe it to be, to the effect that the history and evolution of the molariform premolars furnishes a key or index, by means of which we are enabled to gain some insight into the evolutionary history of the molars themselves, although such direct evidence derived from the pretertiary Eutherians is at present largely concealed from us and missing, we are then ready to proceed to the consideration of the third broad general conclusion in regard to cusp evolution. If the facts and principles embodied in premolar evolution, as originally outlined and demonstrated by Scott, can be depended upon to furnish us a reliable guide to the history of molar development, then we must conclude that *the methods and manner of cusp addition and complication has been different in different groups of the Mammalia*. For this reason alone, no general rule or law of cusp development can be framed, or laid down that will fit or apply to all the groups alike. Thus among the living Insectivora there are no less than three, and possibly four methods or plans that have been concerned in cusp complication and addition to form the molar crowns of these forms. No one, it seems to me, could possibly conceive that cusp evolution could have followed the same course in a form like *Erinaceus*, that it has in such forms as *Chrysochloris*, *Potamogale*, *Solenodon*, or even *Talpa*, even by the most superficial and cursory examination of their molar patterns. They represent so many separate and distinct types of plans of cusp addition, which have little or nothing to do with each other. In the *Chrysochloris-Potamogale* type there have been built up in the superior molars on a

relatively large haplodont crown, a pair of cutting ridges or wings upon the outside, in the form of a V, with the original cusp standing upon the inside at the apex of the figure. The ends of these ridges or arms of the V may be surmounted by faintly developed cusps, but it would be only by the wildest stretch of the imagination that we could believe or assume that they represent a row of original cusps of the tooth crown and that the large primitive cusp has migrated or rotated inwards to its present position. The evidence derived from the fourth premolar clearly disproves and forbids any such supposition, since we there discover these incipient ridges or wings in their first stages of development. Very similar molar patterns to that just noticed are found among the teeth of certain of the Mesozoic Mammalia, upon which Osborn originally based and founded his theory of "Cusp Migration or Rotation," but it is more than probable if we could examine a series of complete and well-preserved specimens of these forms, we would find the same conditions as are now shown in the living *Chrysochloris-Potamogale-Solenodon* type.

Turning next to the upper molars of *Erinaceus*, we note that the tooth crowns are fully quadritubercular, with a fourth premolar in the same condition as that of the molars. While the structure of the crown of this latter tooth has progressed to such an extent as to completely obscure or conceal its manner and plan of cusp addition, just as in the molars, yet an examination of the third premolar clearly reveals the fact that the fourth premolar, and by inference the molars likewise, have added their cusps in a manner not dissimilar to that seen in the Ungulates, Primates, Carnivora and others as shown by the researches of Scott in these orders. The only question that would arise would be as to whether the fourth cusp had been added anterior or posterior in position to the first appearing internal cusp. It will thus be observed that the cusp addition and resulting molar pattern display no characters in common with those of the *Chrysochloris-Potamogale* type above noted, and that the line of the primitive cusp row lies upon the outer side of the crown and not upon the inner side as in that type. It appears perfectly evident, therefore, that the *Chrysochloris-Potamogale* type could not have formed nor does not correspond to any step or stage in the development of the molar crowns of *Erinaceus*, but on the contrary, are constructed upon an entirely different and distinct plan. In the molar pattern of *Talpa* and so many others like it, another modification is introduced. An



analysis of this pattern shows that in some respects it resembles that of the *Chrysochloris-Potamogale* type, while in others it resembles that of *Erinaceus*. The outer moiety of the crown exhibits two main cusps from each of which a V-like extension or wing is projected to the outer border. The resulting pattern of this part of the crown is, therefore, a double V or W whereas that of the *Chrysochloris-Potamogale* type is single. In addition to this W pattern on the outer side of the crown in *Talpa*, there is a large lunate cusp occupying the entire inner moiety. Now on the basis of the Premolar Homology theory it is not difficult to analyze such a crown pattern with satisfaction and success. We at once locate the line of the haplodont or primitive original cusp at the inner anterior point of the W. The cusp standing at the posterior inner point of the W is the second main cusp to have been added, and the large internal lunate cusp was the third in the order of appearance. In this respect, therefore, it resembles that of *Erinaceus*. The wing-like extensions which go to make up the remaining part of the W are new, purely adaptive structures, which have been added to the crown in response to the needs of its possessor, just as have been the similar structures that are found in the molar crowns of *Chrysochloris*, *Potamogale*, *Solenodon* and others. This W pattern on the outer side of the molar crown, it may be added, recurs with great frequency in many distinct and widely separated groups of mammals, and as in those above noted, is simply an adaptive modification, independently acquired, with little or no morphological significance.

A considerable number of different groups of mammals have, however, apparently adopted a mode of cusp addition to build up their molar crown patterns upon a very similar, if not identical general plan, if we are permitted to judge the matter on the basis of the Premolar Homology theory. Thus in the Carnivora, Ungulata, Primates and many Insectivora, the general plan of cusp addition has been very similar. A description of the upper molars and premolars of the extinct Creodont, *Dissacus saurognathus*, from the Torrejon stage of the Basal Eocene, of which I have published an excellent figure in the papers above referred to (Part 1, figure 63 p. 94 Separata), will serve to illustrate this plan of cusp addition very well. It will serve at the same time to illustrate in the most direct manner the relationship between the structure of the molars and premolars and should be carefully consulted. The description is as follows:

The first and second premolars have simple premolariform crowns, and are more or less conical, laterally compressed teeth, implanted by single roots, which we have reason to believe are not far removed in structure from the simple haplodont form of which all the tooth crowns of the series originally consisted. A ridge descends from the summit or apex of the crown on the posterior slope and passes into a thickened shelf or ledge at the base. This ledge is spoken of as the heel of the crown. The third premolar has a triangular outline when viewed vertically by reason of the fact that the heel has grown out to a considerable extent upon the outer side of the crown and an internal ledge or cusp has appeared upon the inner face at the base opposite the main cusp. It is also of the greatest interest to observe that a small cuspule has appeared near the base of the posterior descending ridge. In the succeeding tooth or the fourth premolar these same elements are present, but have developed into stronger structures; the internal cusp is much larger and stronger and the cuspule has developed into a sizable cusp although considerably inferior in size and strength to the main cusp. A small intermediate cusp has also been developed, but this disappears in the succeeding molars. The molars are fully tritubercular, but it is of the utmost interest to observe that the postero-external cusps have never quite attained the size of the main cusp, and as in the fourth premolar are a little smaller. We are thus enabled to discover in such a series of teeth as that above described just how each element of the more complex crown has been added as well as the successive changes through which it has passed from the simple conical stage to the three cusped condition. Nor could anyone, it appears to me, fail to pick out from among the various cusps, the location, position and true representative of the original conical cusp, representing the simple premolar in each and every one of the complex teeth with the utmost certainty and precision.

In the inferior premolars and molars, the changes from the simple, one-rooted, conical or haplodont condition to the complex or tuberculated form can be traced with the same precision and accuracy. If we take as a starting point, a transversely flattened conical crown, a complicating premolar in any of the groups above mentioned passes through the following stages: The posterior portion of the crown is at first extended backwards and develops a second or posterior root. The posterior face of the crown becomes somewhat thickened from side to side and more or less flattened from before backwards,

so as to present on this face a flattened triangular area with the apex of the triangle at the summit. This area looks upwards and backwards and is bounded on either side by descending ridges, which pass into a thickened ledge at the base or the heel. On the inner descending ridge bordering this triangular area, a small cusp or cuspule is developed near the summit, which is small at first and which stands internal and slightly posterior to the main cusp. Simultaneously the heel broadens and thickens in such a way as to become more or less basin-shaped and two cusps are developed on its borders, one upon the outer edge and one upon the inner edge. If the tooth in question is destined to become of a simple quadritubercular form, then the further development of these elements and their further increase in size is all that is required to render the crown molariform. This type of molar crown is found in nearly all the Ungulates and is exceedingly common among the early Primates. And these are essentially the steps and stages through which it passes. If, on the other hand, the tooth is destined to become tuberculo-sectorial, a type of molar crown which is found so often in the Carnivora, then in that event a cusp is developed at the base of the anterior slope of the primitive or conical crown, which grows up to an equal size with that of the main cusp and that of the one which is developed internal with the latter, while the cusps of the heel remain in abeyance. In this type of tooth the three anterior cusps are enlarged and stand, one each at the corners of a triangle. This part of the tooth is then spoken of as the trigon, and it is exclusively from this part of the crown that the shearing blades of the lower sectorials of the Carnivora are developed. In the quadritubercular crown of the lower teeth of the groups above considered it is not difficult to locate the primitive cone at the external angle of the tooth, just as we do in the superior series.

While the method of cusp addition above outlined is found in the Ungulates, Primates, Carnivores and some Insectivores, there is some very direct and positive evidence that this is not true of certain of the Rodents, at least. The philogenetic history of this important and highly modified group of the Mammalia is very little understood. In some few of them the patterns of their molar crowns are comparatively simple, while in others they are among the most highly complex and complicated structures to be found in the entire Class. They are undoubtedly a very ancient group of mammals, since the few remains that are known from the Lower Eocene are almost as highly modified



as the corresponding representatives living today. One of the most abundant forms at this stage is the genus *Paramys*, which has been considered by many students to belong to the Sciurormorph division of the order, ancestral to the squirrels and spermophiles. Miller and Gidley have, however, recently thrown much doubt upon this view and consider them ancestral to the living Haplodonts, which is probably correct. Be this as it may, however, the fourth lower premolar of *Paramys* is in such a stage of evolution as to exhibit most clearly the order of addition of the various cusps of the simple quadritubercular crown of which the lower molars are composed. As we have seen in the description above given, the structure destined to become the antero-internal cusp arises as a small cuspule upon the internal descending ridge of the posterior triangular area on the posterior facies of the crown. Now in *Paramys* a cusp is developed in this situation, but instead of arising on the *inner descending ridge of the triangular area*, it arises on the *outer descending ridge and becomes the antero-external cusp of the completed crown when fully developed instead of the primitive cone which then becomes the antero-internal cusp of the fully developed tooth*. This same condition is found in the living squirrels and spermophiles and constitutes a method of cusp addition for these teeth that is radically and fundamentally different from that already noticed. I called attention to this matter in my papers above quoted nearly twenty years ago, but apparently no heed has been given to it since. I have been unable to learn how cusp addition takes place in the superior series, nor is anything definitely known up to the present how the remarkably complicated tooth crowns of the other groups of the order have been formed.

There is yet another group in which the phylogenetic history has been sufficiently recovered and deciphered to make out the manner of cusp addition and complication with more or less certainty, and while I am not just at this moment in a position to state the facts in all their detail, through lack of access to the necessary specimens, yet I have been convinced from the main facts for many years past, that the plan adopted by this group in the matter of their cusp complication has been unique and peculiar to a high degree. I refer to the order Amblypoda or Dinocerata. The first representatives of this assemblage are found in the Torrejon stage of the Basal Eocene and include animals of moderate proportions, none of which are larger than a large boar. From this stage they continue with increasing represen-

tation through the Lower and Middle Eocene into the Upper Eocene, terminating in the great horned type *Uintatherium* or *Dinoceras*, which marked the termination and extinction of the line. In the earliest member of the series thus far known (*Pantolambda*), the anterior premolars have more or less simple, laterally flattened crowns, supported by single roots. Those of the superior series exhibit a progressive development from before backwards, and possess a pair of wing-like extensions in the form of a V, radiating from the primitive or haplodont cusp. These wing-like ridges are faintly developed in the anterior premolars and become progressively more marked in the third and fourth premolars, where they are projected outwards towards the outer border of the crown, in a manner not at all dissimilar to that already noticed in the molar crowns of the *Chrysochloris-Potamogale* type of the Insectivora. The resultant tooth crowns of the molars are a series of figures resembling in outline that of the Greek letter lambda, a fact from which Cope named the genus. The thickening of the outer or terminal limbs of the wing-like V extensions into cusps, produces a tritubercular crown pattern from which the latter or more complex forms in the group have arisen. The principal or internal cusp, therefore, represents the original or haplodont cone, instead of that of the antero-external, as in many of the groups above described.

With the groups already considered, there yet remain vast assemblages of mammals, whose molar teeth have undergone a high degree of complication and evolution from undoubted primitive stages, but whose history, unfortunately, is almost a total blank to us as far at least as their molar evolution is concerned. Such orders include the Sirenia, Proboscidea, Hyracoidea, Toxodontia, Astrapotheria, Pyrotheria, Litopterna, the great majority of the Rodentia as well as many others. However, in any and all of these forms, if in the primitive stages any of the premolars had advanced towards a molariform condition, and their remains can be discovered, the doctrine of Premolar Homology may be depended upon to reveal the various steps and stages through which the molars have advanced from their primitive to their specialized state.

In such forms as those whose history we have been able to follow throughout the geological past, we have seen how the tooth crowns have arisen from the haplodont stage to the tritubercular stage in the superior series, and from the haplodont stage to the tuberculo-sec-

torial or quadritubercular stage in the inferior series, and at this point we forsake the region of deduction supplied by the theory of Premolar Homology and enter the realm of the great theory of Trituberculy of Cope, published in the Proceedings of the American Philosophical Society in 1883. The broad generalization sought to be established by this theory is one of the most important and far reaching deductions within the whole range of mammalian morphology, and is a performance in every way worthy of the great master mind that conceived it. It is one of the many enduring monuments that will stand to the credit of this greatest of all American morphologists as long as the science is cultivated.

It is to be observed that Cope's theory of Trituberculy, as the name implies, sought only to reduce the highly developed and complex molar patterns to the basis of the simple three-cusped stage, and his researches and discoveries were largely to this end. These studies were mostly made upon the Amblypoda, Phenacodonts, Ungulates, Primates, Carnivores and related groups, and it is largely upon the molar evolution of these orders that the generalization rests. In this, Cope's researches have been epoch-making, and it was almost wholly through these efforts that the evolution of the complex and complicated molar patterns of these forms was first completely understood. In the further development and elaboration of this subject, the researches of Cope have been powerfully supplemented by the work of Scott and Osborn, especially the latter, who has contributed greatly to our knowledge along these lines. It is further to be noted that in proposing the Tritubercular theory Cope never sought to go beyond the tritubercular stage, but rested content with the demonstration that all complex patterns were reducible to, and had arisen from this condition. This, therefore, may be enunciated as the fourth broad conclusion in dental evolution to which we may give our assent, as either demonstrated or in a fair way of proof for all orders of mammals.

In connection with Cope's great theory of Trituberculy, Osborn, from a study of the Mesozoic Mammalia, endeavored to introduce a further broad and far-reaching generalization, which was at the time supposed to account for the origin of the tritubercular crown from the haplodont or single-cusped stage. He assumed that a small cusp was added to the base of the crown of the single-cusped tooth, on the anterior and posterior edges, constituting his triconodont stage. The next step in complication he conceived to be a shifting, a migration



or rotation of these cusps in line, so that each cusp came to occupy the angle of a triangle, or in other words, the main cusp shifted to the inside in the upper series of teeth and to the outside in the lower series. This has been called the theory of Cusp Migration or Rotation, and upon the basis of this conception he proposed an elaborate and detailed nomenclature of the cusps of the mammalian crown, by means of which it was supposed that the position of the modified haplodont cone could be infallibly located and identified in the complex crown. To this he gave the name *protocone*, meaning the first in the order of appearance in the series of cusps. To the others of the tritubercular crown he gave the less committal names *metacone* and *hypocone*. This conception of the manner and order of appearance of these elements of the three-cusped crown have, unfortunately, proven inaccurate and wholly lacking in application, since as we have already seen that the three cusps of the tritubercular stage arise in diverse and different ways according to the deductions of the Premolar Homology theory. I have registered my objections to the retention of the nomenclature of the cusps proposed by Osborn in the papers above quoted, largely on the ground that they are primarily based upon an erroneous conception of the manner in which the three-cusped stage arose, and that the principal name of the series, viz: the *protocone*, is misleading and erroneous in the great majority of the teeth of the Mammalia. It is, of course, a matter of individual choice largely what name we apply to these structures, but I hold that a continued use of a system of names, principally founded and conceived in error is fraught with danger to the integrity of the science which we seek to cultivate and advance.

## DISTRIBUTION OF HAIR ON THE DIGITS IN MAN\*

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The distribution of hair on the digits is of especial interest from an evolutionary standpoint and because of the light which it may shed on the mechanism of hair regulation in general. In man, hair is commonly present on all the basal segments of the digits and invariably absent from all the terminal ones. On the middle segments there is wide fluctuation with apparent familial and racial tendencies. It is, consequently, the middle segment which offers the most promising field for investigation and which is chiefly considered in this paper.

The number of persons examined, together with the nature of the observations in each group, is indicated in table I. The data were all collected by the writer except those in group 14 and a part of those in group 13. In group 13 they were collected by experienced observers and are probably quite as accurate as those in the preceding groups. The observer for group 14, while intelligent and carefully instructed, was not, like the others, a trained student and was further handicapped by the necessity of working rapidly, which, among other things, precluded the use of a lens in doubtful cases. This leaves his figures open to some question and they will consequently be treated separately and with caution. They are not entirely excluded since they do have a very definite value in some connections.

In addition to studies on the living, serial sections of adult and foetal digits or parts of digits have been utilized. For comparative purposes, it has been possible to examine the hands and feet of a considerable number of monkeys of various species, and also the skins of anthropoid apes in the Smithsonian and American Museums. While the amount of the latter material was not so great as might have been desired, it was sufficient to be of at least some value.

\*The author is indebted for various data and facilities to the Office of the Surgeon General and to officials in charge of several institutions and collections. The expenses have been defrayed from a fund given the Washington University School of Medicine for study of hair.

In many, if not all, of the lower Primates there is a hairy region on the dorsum of each digit, continuous proximally with the hairy covering of the metacarpus, or metatarsus, and extending distally nearly to the base of the nail. In man, and some of the anthropoids, this tract is reduced in extent and more or less broken up into circumscribed areas. The skin over the distal interphalangeal articulation is always free from hair in the human species. That over the middle articulation is apparently likewise invariably free, despite the fact that hair is commonly present both proximally and distally to this joint. Over the articulation at the base of the digit, hair may be either present or absent. Of the three segments of the digit, the distal, as is well known, is without hair in man, and in an occasional individual anthropoid, the middle segment may or may not bear hair, while the basal rarely if ever lacks it. There is evidence of a tendency toward reduction from the presumably primitive continuous band of hair first to two small islands and then to a single one, the latter located over the basal phalanx.

So far as the distribution of hair is concerned, the thumb and great toe are digits lacking a middle segment. It may also be noted parenthetically that such observations as it has been possible to make do not sustain the suggestion of Wood-Jones ('20)<sup>1</sup> that a tuft of hair over the basal phalanx of the great toe is a distinctively male characteristic, such a tuft being frequently present in women and sometimes poorly developed in men.

The character of the hair on the middle segment of the digits is of especial interest since it is in this region that the process of reduction in the pilary system seems to be going on most actively. Upon examination of a sufficiently large number of cases certain individuals are found who have hair on the middle segments of all their digits. In some instances these hairs are well developed and almost as numerous as those on the basal segments. From this extreme in the plus direction, which is remotely suggestive of the distribution in the orang, a finely graded series could be arranged with the successive members showing progressively fewer hairs until at the other extreme a group would be reached in which there are no hairs whatever on any of the middle segments. Another series could be made to show a reduction in the development of individual hairs. The two series, however,

<sup>1</sup>WOOD-JONES (FREDERIC), *The Principles of Anatomy as seen in the Hand*. Phila., 1920, 319 pp



would not necessarily coincide, since in some individuals the one or two hairs in the whole region are long and robust while occasionally in one of the same degree of general pilosity the hairs, while perhaps relatively numerous, are so fine and short as to be easily overlooked. In some cases where no hairs are actually visible the pits of hair follicles can be seen, and in microscopic sections these are found to contain either rudimentary or regenerating shafts. The occasional complete absence of hair from the middle segment of the digit can be conclusively demonstrated by means of serial sections in which the skin is shown to be, like that of the distal segment, wholly without trace of hair follicles. This condition has been found in sections of skin from the fourth fingers of adult and of foetal material of various ages, indicating that the hair may be definitely present or absent from a very early period in the life of the individual.

It will be apparent from the foregoing that the sources of error which must be most carefully guarded against are, in the one instance, mistaking the presence of very fine or rudimentary hair for the absence of hair, and in the other, mistaking chaps or minute depressions for the mouths of follicles. In the examination of considerable numbers of living subjects it is possible that both of these errors are occasionally made.

A second point in regard to the digital hair concerns its distribution among the digits. It was found on inspection, that, in man, hair is absent from the middle segment of the toes much more frequently than from the middle segments of the fingers. Of the 442 soldiers in group 1 hair was absent from the middle segments of all the fingers in 131 cases and from all the toes in 371 cases. In this group hair was present on the middle segment of the index finger in 25 instances, on that of the middle finger in 215 instances, of the ring finger in 309 instances, and of the little finger in 149 instances. The numbers for the corresponding segment of toes 2 to 5 were 43, 60, 27 and 2 respectively. These facts may be stated in another, and possibly more illuminating manner, as follows:

Of all fingers bearing hair on their middle segments:

44.2 per cent were digits 4  
30.8 per cent were digits 3  
21.2 per cent were digits 5  
3.8 per cent were digits 2

Of all toes bearing hair on their middle segments:

45.4 per cent were digits 3  
32.6 per cent were digits 2  
20.5 per cent were digits 4  
1.5 per cent were digits 5

The significance of these relations will be discussed in a subsequent paragraph.

In table II is shown the distribution of hair on the middle segments of the fingers in several different groups, the data being entered as percentages to facilitate comparison. It may be seen from this table that if hair is present at all, it almost invariably (in about 99 per cent of the cases) appears on the fourth finger. Frequently it occurs on this digit only; for example, in 20 per cent of group 1. More often it is present simultaneously on the third, fourth and fifth fingers (26.9 per cent), less frequently on only the third and fourth (15.6 per cent) and rarely on all four fingers (5.2 per cent). Other combinations are quite infrequent. Stated conversely, hair has in most instances disappeared from the middle segment of the index finger while in a considerable number of cases it is also absent from the corresponding segment of the fifth, and frequently also that of the third finger. The last finger to lose its hair is the fourth.

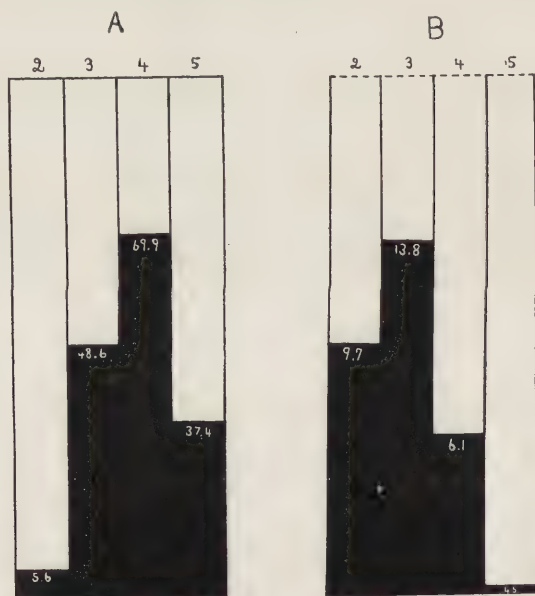


Figure 1. Diagrams to show the relative distribution of hair on the middle segments of digits of the hand and foot, based on the data from group 1. The four vertical columns represent the totals for digits 2 to 5 as indicated, the shaded portion at the base showing the percentage of each which was found to have hair on the middle segment. A represents the fingers, B the toes. B is the base of a polygon ten times as high as A.

There were 71 individuals in group 1 with hair on the middle segment of the toes and these showed the following distributions: hair on digits 2, 3, 4 and 5, two; hair confined to digits 2, 3 and 4, fourteen; to digits 2 and 3, eighteen; to digits 3 and 4, eight; to digit 3, eighteen; and to other combinations, eleven. In the foot it is digit 5 and not 2 which most frequently lacks hair, and digit 3 which most commonly has it. In group 14 hair is recorded as absent from the toes in a much higher percentage of cases than in group 1, which is probably due in part to incomplete examinations. In any event, of the 9991 soldiers examined in this group, 412 are recorded as having hair on the middle segment of one or more of the toes. Of these 361 have hair on the third toe, 279 on the second, 84 on the fourth and 23 on the fifth. While the percentages for the several toes in group 1 and group 14 are not the same, they do fall into the same sequence and the values in each case are separated by wide margins, which seems to establish beyond doubt that the toes arranged in the order of the frequency in which they bear hair stand in the order 3, 2, 4, 5. This is in clear contrast to the relations of the fingers which are shown by all the groups to be in the order 4, 3, 5, 2. The distribution of hair on fingers and toes, as exemplified in group 1, is shown in figure 1, A and B.

While it is in many ways convenient to consider the digits as individual units, the distribution of hair upon them suggests that they might better be regarded as a group and the middle segments of digits 2-5 inclusive considered as a single region. In the hand there is found to be a center, on the fourth finger where hair is most certain to be present. If there is only a little hair it is found at this point. If more is present it spreads to either side, but more readily in the pre-axial direction, reaching the third more often than the fifth finger. On the pre-axial side it sometimes extends to the second finger which forms a limit in that direction, as the fifth does in the post-axial direction. With the toes the condition is precisely the same except that the "hair center" is over the third digit rather than the fourth. The extension from this point is also more apparent in the pre-axial direction so that here digit 2, like digit 3 of the hand, is second in point of hairiness. In the post-axial direction digit 4 of the foot is about comparable to digit 5 of the hand, and digit 5 of the foot, farthest removed from the center, is most often without hair. If it should be subsequently established that we have to do in this region solely with inhibition of hair growth, the statement of these relations would have to be put



conversely, the hair center being the point of greatest resistance to the factors that inhibit hair growth. Since hair is not often present toward the periphery of these regions unless it is also present at the center, figures 1A and 1B approximate closely to curves for the incidence of hair over the mid-digital regions of the hand and foot. The curves are very similar, except that their modes are at different points. One is of necessity truncated on the left, the other on the right. Both are skewed to the left.

Although there is, as has been shown, a much stronger tendency for hair to be present on the fingers than on the toes, it is clear that there is some correlation between the two regions. In group 1 there was no instance of hair being present in the toe region and absent in the finger region, while 60 per cent of the persons having hair on all four fingers also had hair on some of the toes, as contrasted with 13.6 per cent of those with one or more fingers bare. (In group 14 hair on the toes is recorded seven times as frequently for individuals with hair on all the fingers as for other members of the group). These facts perhaps simply indicate that the two regions possess certain inherently similar potentialities, or respond in a somewhat similar manner to regulatory influences, without, however, showing anything like identity.

The extent to which the influences regulating hair in these regions are common to both sides of the body was studied by examining the distribution on the right and left hands in one series and the number of individual hairs on the fourth fingers of another series. In dealing with bilateral structures of this sort one may conveniently speak of the percentage of cases in which the structures are symmetrical as the index of symmetry. In groups 2 to 5 inclusive, this index is 89, in groups 6 and 7 it is 90, and in group 8 it is 87.5. Comparing the actual number of hairs on the two sides the index of symmetry for groups 2a, 3a, 4a, and 5a was 88.9. In other words, this analysis shows that in about nine cases out of ten the two sides are essentially similar. If from the last mentioned groups the cases in which the two sides differed by only one or two hairs were eliminated the index would be raised to about 95. By way of comparison it may be mentioned that in a series of 21 dissected bodies the index of symmetry of the pectoralis minor muscle was 90, of the pectoralis major, 85, of the levator scapulae 95, and of the brachial artery, 80. These data seem to indicate that while the amount and distribution of hair in the mid-

digital region is subject to a wide range of variation between different individuals, the factors which control the hair on the two sides of the same individual are of about the same strength as those which control the symmetry of certain other anatomical structures. There was found to be an excess of hair in the mid-digital region on the right side in 26 cases and on the left side in 15 cases, when the number of fingers bearing hair was considered, and an excess on the right side in 15 cases and on the left in 29 cases when the actual number of hairs on the fourth digit was taken as the criterion.

The relation between hair on the mid-digital region of the fingers and hair on other parts of the body was investigated in groups 1 to 5a inclusive. In group 1, the 442 individuals examined were placed in four arbitrary grades based on the amount of hair on the body and limbs. Grade 1 included 259 individuals who had but little hair in excess of that common to the "female type;" grade 2 was made up of 107 persons with a moderate amount of hair on the chest and abdomen; grade 3 comprised 53 men showing a somewhat greater amount of hair; and grade 4 contained the remaining 23 cases which represented extreme degrees of pilosity. In the other groups four arbitrary grades were also made, but this time based on the development of hair over the basal phalanges.

When the general pilosity of the body is compared with that of the mid-digital region no clearly significant correlation is found, hair being absent from the four grades in 31, 29, 28, and 21 per cent respectively. While this series is arranged inversely to the order of general hairiness, the total of the values (442) is by itself too small to be above question. The values derived from a comparison of the basal and middle segments of the fingers of white clinic patients (680 cases) shows a similar but more marked relation, hair being absent from middle segments of fingers graded 1, 2, 3, 4, in the ratio of 4.3 : 3.4 : 2.3 : 1. (This is approximately 4 : 3 : 2 : 1). In the colored patients (303 cases) hair is absent from the corresponding groups in 97, 90, 73 and 70 per cent of cases. Since the figures based on these 1425 cases are all consistent the conclusion seems warranted that there is some degree of correlation between the presence or absence of hair on the middle segments of the fingers and the luxuriance of hair on the basal segments, and on the body in general. The figures show more or less clearly, however, that this correlation is not of a

very high order and that the mid-digital region possesses a considerable degree of autonomy.

Turning now to the question of the distribution of types with reference to race and sex, it may first be noted that in all cases of comparable groups from the two sexes it is the female group that shows the higher percentage of cases without hair on the mid-digital region and in general the lower grade of pilosity for individuals in whom hair is present in this region. This apparent relation is undoubtedly the true one, but it must be pointed out that since the data in table II are all based on examinations of the living they could not be checked by anything more than a hand lens examination which possibly fails to detect a certain number of the most rudimentary hairs and hair follicles. Very rudimentary hair is more common in the female than in the male.

It was hoped that group 14 would afford satisfactory data for comparing the males of different races in so far as those races might be judged from the nationality of the subjects or their immediate ancestors, but, while some differences do seem to be revealed they are not of sufficient certainty to warrant a detailed discussion at this time. In those groups, however, that can be separated on color lines, racial tendencies are clearly marked. Groups 4 and 5 represent urban negroes in which there is, no doubt, a certain admixture of white blood. 10a and 10b represent a people who are perhaps more negro than Indian and who also have some white blood. These groups not only show a very high percentage of individuals with complete absence of hair from the mid-digital region, but of those with hair a relatively large number have it confined to digit 4. Very few have hair on three digits, and none on four. Groups 11a and 11b represent Indian without negro admixture, but with some infusion of white. These people showed a greater amount of hair on the mid-digital region but with relatively few having three digits involved and none with four. No case of an undoubtedly pure blooded negro or Indian was found with any hair on any part of the mid-digital region, but the number of such individuals was very few. Whether or not hair has wholly disappeared from this region in these races, as it has from the terminal region of all races, can only be settled by an examination of more extensive material.

The twenty-five men in group 12 were sailors on a Japanese warship and presumably represented pure stock. Of these, seventeen



lacked hair in the mid-digital region, two had it on digit 4, four on digits 3 and 4, and two on digits 3, 4, 5. All of these data taken together show that the Indian, the negro, and the Japanese, as races, have gone farther toward freeing the mid-digital region of hair than has the white race, although certain members of the latter race have reached a stage quite as advanced as that of any representative of the colored races.

It is interesting at this point to review the condition in other primates. Table III summarizes the data available to the writer. It should be mentioned here that Friedenthal ('08)<sup>1</sup> has noted the absence of hair from the middle segments of the fingers of some apes, and attributed this absence to attrition caused by walking in the semi-erect position with the dorsum of the finger on the ground. The photographs accompanying Miller's article ('20)<sup>2</sup> show clearly how this might occur. While the habit may be a factor in keeping the hairs worn down, it is not clear that it would make them actually disappear, nor does it explain very satisfactorily variations in the amount of hair on the fingers. It completely fails to explain the frequent absence of hair on the middle segments of the toes. The point mentioned, however, adds to the difficulty of a correct diagnosis, especially in dried skins of the hands.

The three gibbons, like most lower monkeys, had hair on all segments of all the digits. Of the seven orang outangs, all had hair on the middle segments of all the digits, while three lacked it on the terminal segments of the fingers and two of these on the terminal segments of the toes. Members of the human race showing this pattern are occasionally met with. Chimpanzees show a more constant presence of hair on the terminal segment, only one out of twelve lacking it, on digits 4 and 5 of the hand, and two out of seven on digit 1 of the foot. The middle segment, however, seems to be freer from hair than is the corresponding region in (white) men, only three out of twelve having any hair in this region of the hand. Finally the gorilla, so far as may be judged from three specimens, agrees with the orang in its tendency to lose hair from the terminal segment and with the chimpanzee in the relative absence of hair from the middle

<sup>1</sup>FRIEDENTHAL (HANS), Beiträge zur Naturgeschichte des Menschen. Jena, 1908.

<sup>2</sup>MILLER (GERRITT S.), Problem of Man's Ancestry. *Am. J. Phys. Anthropol.*, 1920, III, No. 2, 213-245.

segments. The right hand of the last specimen in the list has, so far as the digits are concerned, the distribution of hair characteristic of the Indian and negro and found in approximately thirty per cent of white persons.

These facts are of significance since they show clearly that the tendency to lose the hair from the terminal and middle segments of the digits is present not only in man but also in anthropoids, and since they indicate that the two regions have a certain degree of autonomy. Man alone, as a species, has lost all hair from the terminal segments of his digits. In this he has gone farther than any anthropoid. With reference to the middle segment the gorilla and chimpanzee seem to have definitely surpassed the white race and nearly equalled the negro. Probably no one would suggest that these relations have any phylogenetic significance beyond indicating that the variability in the pilosity of these regions has its source in something common to the several forms, something which may perhaps have been derived from some more or less remote common ancestral type. It would indeed be difficult to regard the similarity between the pilosity of certain gorilla and human hands as any thing other than instances of parallel or convergent evolution, and perhaps the similarity between the hands of certain whites and negroes may best be regarded in the same way.

The question as to whether the conditions observed in different individuals of the same race are of a sporadic or hereditary nature was studied in eighty families with a total of 178 children. Five of these children, representing two families, had more hair on their fingers than either of their parents. In one family the parental maximum was hair on digits 3, 4 and 5, but two of the children had hair on digits 2, 3, 4 and 5. In the other family both parents had a somewhat unusual distribution of mid-digital hair which was confined to the fourth and fifth fingers. They may have been aberrant representatives of the 3, 4, 5 group, but, be that as it may, three of their children had hair on those digits. It is rather surprising to find that in none of the remaining 173 children did the degree of digital pilosity exceed that of the most hairy parent, indicating that the presence of hair in almost any degree is generally dominant over all conditions representing less amounts. The character of the matings and the nature of the progeny are set forth in condensed form, in table IV. The data in this table are fairly consistent with expectations based on the

assumption that the absence of hair in the mid-digital region is due to a recessive trait, most of the matings studied presumably having at least one homozygous parent. Unfortunately no cases were found in which two white parents lacked hair on the whole mid-digital region. Such families were found among Indians and negroes, and in these cases the children were like the parents. There is obviously some evidence that the above mentioned recessive trait is not due to a single gene or, if so, that its manifestation is complicated by modifying factors. Matings in which one parent had hair on all four digits produced children with hair on all four digits relatively about twelve times as frequently as did parents with one or more digits free. This phase of the problem needs further study but the evidence indicates that what seems to be a phylogenetically progressive loss of hair is brought about through the action of one or more recessive genes, or of one primary recessive gene with several modifying factors that regulate the distribution of hair when it is present. Sex may be one of these modifying factors. Stated conversely, it appears that, despite the fact that in evolutionary progress hair is disappearing from the mid-digital region, its presence here may be regarded as the manifestation of a dominant trait. These family histories, fragmentary though they are, make it appear that the amount and distribution of hair on the mid-digital region, is not merely a matter of species, or even of race, but is a familial characteristic with its basis in the individual germplasm.

The foregoing paragraphs set forth the principle findings that it is desired to report in this communication. There remain, however, two or three general considerations that may appropriately be discussed in this connection.

One of these concerns the development and physiology of the digital hair. Unfortunately our knowledge here is not so complete as might be desired and our ideas must for the present be based largely on inference. It has been pointed out that there is not a very good correlation between the amount of hair on the mid-digital region and the apparent amount on the body as a whole. It may be added that among women with more or less marked hypertrichosis, individuals are found with no hair on the mid-digital region, with the hair confined to one or two fingers, and with it extending to all the fingers. In such women especially, and also in the great majority of men, the hairs that are present generally show an individual development pro-



portional to the hair on the rest of the body.<sup>1</sup> This phenomenon would be explained if it could be shown, as some of our data suggest, that one set of factors determines how many follicles shall be formed while quite another set regulates the growth of the individual hairs. It might be equally well explained if it were shown that there are inhibitory factors which can suppress a follicle, if effective at some critical period in its ontogeny, but which subsequently can have at most no more than a depressing effect on its development. If the latter suggestion should prove to be the correct one, a study of the mid-digital region might become of importance in the understanding of certain conditions of supposed endocrine origin.

Another matter of theoretical interest is the relation of the mid-digital region of the hand to that of the foot. The similarity of the curves for hair distribution in the two regions is most striking except for one point—the peak of the curve is one digit further toward the pre-axial side in the foot than in the hand. This is not the only respect in which the hand and the foot differ in this way. It is universally recognized that the axis of the hand passes through the third finger while that of the foot passes through the second toe. Associated with this fact are anatomical differences, particularly in the interosseus muscles which, like the hair on the surface, have their central point in the foot, moved forward as compared with the hand. Another striking indication of the same relation is revealed in the occurrence of syndactyly. It appears from the data which the writer has been collecting for some time that in the great majority of cases in which syndactyly occurs in the hand it is digits 3 and 4 only that are united, while in the foot it is digits 2 and 3 only. In some cases at least the friction ridges of the syndactyl fingers are continuous showing that the condition represents not a fusion of digits but a failure of digits to separate, thus eliminating any possible influence of the interosseus muscles as a causal factor. We can only conclude from these relations that the individual fingers and the individual toes are not serially homologous. If homologies are to be drawn, they must be drawn between the whole digit regions which produce, in general, the same number of digits but not digits which can be fully homologized one with another. In other words, the part of the hand and the part of

<sup>1</sup>LE DOUBLE (A. F.), *Les Velus. Contribution a l'Etude des Variations par excès du système pileux de l'homme et de leur signification au point de vue de l'Anthropologie Zoologique.* Paris, 1912.

the foot which are represented by digits of the same numerical denomination are not strictly comparable parts.

Finally, it is significant that there seems to be a common tendency, running through all the higher Primates, which leads towards a denuding of the fingers and toes. This may be a part of, or associated with, a general tendency to depilation, but in man, at least, the mid-digital region shows a considerable degree of autonomy, and so it apparently does in the apes, since three very heavily coated gorillas had less hair on their hands than did the sparsely covered chimpanzees. From a phylogenetic standpoint such matters are of interest, but their interpretation is difficult. It is perhaps simplest to imagine that the tendency to hair reduction has arisen independently in several genera, just as, for example, polydactyly has arisen spontaneously time and again in widely separated forms. A tendency to small mutations in the direction of hairlessness may be a characteristic of primates, as Duarden ('18)<sup>1</sup> believes small mutations in the direction of plumelessness to be a characteristic of the ostrich group. Studies of lethal factors and certain experimental work on germ cells indicate that the effectiveness of these elements as producers of viable embryos

TABLE 1. SUMMARY OF THE SOURCE AND NATURE OF THE DATA

Group	Subjects	Nature of Observation	Number of Cases
1	White soldiers	Fingers and toes of left side	442
2	White males (civilians)	Fingers of both hands	180
3	White females	Fingers of both hands	193
4	Colored males	Fingers of both hands	74
5	Colored females	Fingers of both hands	103
2a	White males	Only fourth finger of each hand	149
3a	White females	Only fourth finger of each hand	185
4a	Colored males	Only fourth finger of each hand	49
5a	Colored females	Only fourth finger of each hand	105
6	Feeble-minded males	Fingers of both hands	49
7	Feeble-minded females	Fingers of both hands	56
8	Insane males	Fingers of both hands	151
9	Insane females	Fingers of both hands	645
10a	Shinnecock Indian males	Fingers of both hands	28
10b	Shinnecock Indian females	Fingers of both hands	22
11a	Penobscot Indian males	Fingers of both hands	55
11b	Penobscot Indian females	Fingers of both hands	45
12	Japanese sailors	Fingers of both hands	25
13	Miscellaneous families	Fingers of both hands	361
14	White soldiers	Digits on left side	9991

<sup>1</sup>DUERDEN (J. E.), Some Results of Ostrich Investigations. *S. Afric. J. Sc.*, 1918, XV., 247-284.

may be in some measure wrapped up with the nature of the determiners, or genes, which they carry. If such be the case, it is clear that traits of no real value to their possessors may ultimately prevail in a species, provided only they are not definitely detrimental. In any event, while it is doubtful if the loss of hair from the fingers is of much benefit, there is nevertheless to be observed among the Primates a widespread tendency for it to disappear.

TABLE II. PERCENTAGE DISTRIBUTION OF HAIR ON THE MIDDLE SEGMENTS OF THE FINGERS IN THE SEVERAL GROUPS

Group and sex.	No hair on middle segment of any finger.	Hair on middle segment of fourth finger only.	Hair on middle segment of fingers, 3, 4, 5.	Hair on middle segment of fingers 2, 3, 4 5.	Hair on middle segment of fingers, 3, 4 only.	Hair on middle segment of fingers, 4, 5, only.	Hair on middle segment of some other combination of digits.
1. Male	29.6	20.1	26.9	5.2	15.6	1.6	.9
2. Male	38.9	15.6	20.6	3.3	18.3	2.8	.5
3. Female	54..	17.6	6.2	2.1	18.6	.5	1.0
4. Male	83.7	6.8	1.4	0.	1.4	4.0	2.7
5. Female	90.3	5.8	1.9	0.	1.9	0.	0.
6. Male	35.6	8.9	20.0	6.7	24.4	4.4	0.
7. Female	41.1	12.5	21.4	3.6	19.6	0.	1.8
8. Male	26.5	12.5	35.1	5.3	17.9	2.6	0.
9. Female	34.6	16.6	22.2	6.0	18.9	.9	0.8
10a. Male	96.5	3.5	0.	0.	0.	0.	0.
10b. Female	100.	0.	0.	0.	0.	0.	0.
11a. Male	60.	20.	7.	0.	13.	0.	0.
11b. Female	68.9	31.1	0.	0.	0.	0.	0
12. Male	68.	8.	8.	0.	16.	0.	0.
14. Male	15.2	36.2	42.3	2.6	2.1	0.5	11



TABLE III. DISTRIBUTION OF HAIR ON DIGITS ON ANTHROPOID APES AS REVEALED BY AN EXAMINATION OF SKINS. UNLESS OTHERWISE INDICATED, BOTH SIDES WERE ALIKE. L, LEFT; R, RIGHT; O, HAIR ABSENT; +, HAIR PRESENT. THE NUMBERS AT THE TOPS OF THE COLUMNS INDICATE THE RESPECTIVE DIGITS.

Sex of Individuals	HAND										FOOT									
	Terminal Phalanx					Middle Phalanx					Terminal Phalanx					Middle Phalanx				
	1	2	3	4	5	2	3	4	5		1	2	3	4	5	2	3	4	5	
	Symphalangus klossi																			
Female	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	
Male	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	
Female	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	
	Pongo																			
Female	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	
Male	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	
Male	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	
Male	0	0	0	0	0	+	+	+	+		+	+	+	+	+	+	+	+	+	
Female	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	
Female	0	0	0	0	0	+	+	+	+		0	0	0	0	0	+	+	+	+	
Female	0	0	0	0	0	+	+	+	+		0	0	0	0	0	+	+	+	+	
	Chimpanzee																			
Male	+	+	+	0	0	0	0	0	0		+	+	+	+	+	0	0	0	0	
Male	{L	+	+	+	+	+	+	+	+		0	0	0	+	+	0	0	0	0	
Male	{R	+	+	+	+	+	+	+	+		0	0	0	0	0	0	0	0	0	
Male		+	+	+	+	+	+	+	+		0	+	+	+	+	0	0	0	0	
Female	{L	+	+	+	+	+	+	+	+		0	0	0	0	0	0	0	0	0	
Female	{R	+	+	+	+	+	+	+	+		+	+	+	+	+	0	0	+	0	
Male		+	+	+	+	+	+	+	+		+	+	+	+	+	+	+	+	+	
Female (young)		+	+	+	+	+	+	+	+		0	0	0	0	0					
Female (young)		+	+	+	+	+	+	+	+		0	0	0	0	0					
Female (young)		+	+	+	+	+	+	+	+		0	0	0	0	0					
Female (young)		+	+	+	+	+	+	+	+		0	0	0	0	0					
Female		+	+	+	+	+	+	+	+		0	0	0	0	0					
Male		+	+	+	+	+	+	+	+		0	+	+	+	+					
Male		+	+	+	+	+	+	+	+		0	+	+	+	0					
	Gorilla																			
Female	{L	0	+	0	0	0	0				0	0	0	0	0	0	0	0	0	
Female	{R	0	+	+	0	0	0				0	0	0	0	0	0	0	0	0	
Male		0	+	0	0	0	0				+	+	+	+	+	0	0	0	0	
Male	{L	0	0	0	0	+	0				+	+	+	+	+	0	0	+	0	
Male	{R	0	0	0	0	0	0				+	+	+	+	+	0	+	0	0	

TABLE IV. SUMMARY OF DATA RELATING TO HEREDITY OF HAIR ON THE MID-DIGITAL REGION OF THE FINGERS. ABS, NO HAIR IN THE MID-DIGITAL REGION OF ANY OF THE FINGERS; ALL, HAIR PRESENT ON THE MID-DIGITAL REGION OF FINGERS 2, 3, 4 AND 5; INT, HAIR PRESENT ON THE MID-DIGITAL REGION OF SOME, BUT NOT ALL, OF THE FINGERS.

Character of Parental Matings	Number of Families	Distribution of hair in the offspring.		
		Abs	All	Int
Abs $\times$ All	1	0	0	2
Abs $\times$ Int	8	3	0	11
All $\times$ All	1	0	1	1
All $\times$ Int	22	1	12	46
Int $\times$ Int	48	7	2	92
Total	80	11	15	152

## HEREDITARY AND RACIAL VARIATION IN THE MUSCULUS PALMARIS LONGUS

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### INTRODUCTION

Certain variations in the human muscular system are common and the frequency of their occurrence has been made the subject of numerous, and often extensive investigations. Studies, carried on largely in European laboratories, have made it possible to state with some accuracy the incidence of many of these variations in the general run of dissecting room subjects. It has been shown that the incidence of some of them varies with the sex of the subject and even with the side of the body. Owing, however, to the usual limitations of the material racial peculiarities have been inadequately studied by dissection and, so far as we have been able to learn, study of familial tendencies toward certain muscular variations has been wholly neglected. Indeed, the idea seems generally to have prevailed that variations in the musculature are of a more or less sporadic nature without any special germinal background. The present study was undertaken for the purpose of obtaining more precise evidence as to the sporadic or germinal origin of some common muscular variation.

Since data from the dissecting room were not adequate to settle the question, it was thought that recourse might be had to study of the muscle in living subjects, a method introduced some years ago by J. Parsons Schaeffer ('09).<sup>1</sup> Several muscles seemed to be suitable for this purpose. From among these the M. palmaris longus was selected because of its easy accessibility for examination, and because of the extensive published data relating to it. The interest in this muscle is still further enhanced by the fact that it is one of those whose variability is influenced by the sex of the subject and even by the side of the body, factors which might have seemed a priori to indicate that

<sup>1</sup>SCHAEFFER (J. PARSONS), On the variations of the palmaris longus muscle. (An Abstract). *Anat. Rec.*, 1909, III., 275-278.

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the fundamental cause of its variation is other than germinal. The palmaris longus is frequently absent, and when present is subject to a moderate degree of variability. In this study attention was centered wholly on the question of its presence or absence as revealed by an inspection of the tendons on the volar aspect of the wrist.

After establishing the feasibility of the study of the palmaris longus in the living it was planned to determine the frequency with which it is absent in the general run of white population, studying a group as large at least as any group reported in the literature. Using the data thus obtained as a control, it was next planned to study the distribution of the muscle within a considerable number of families, and finally to extend the observations in so far as possible to different races. In its general outline this program has been carried out, but the number of families studied (102) is not so great as it should be and the extension of the examination to colored races other than negro is wholly inadequate. Over sixteen hundred persons were examined, and it is believed that the data from these examinations not only throw new light on the variation itself but also open up important new problems in the fields of human ontogeny and genetics.

#### MATERIAL AND METHODS

White, negro, Indian and Japanese subjects were examined. The white subjects, all of whom were examined in St. Louis and vicinity, were persons of the usual European descent, including those of British, Scandinavian, German, Hungarian, French, Italian, Jewish and mixed ancestry. They represented various classes of society, including students, clinic patients and laborers. They were not confined to any one age group. Both sexes were included.

The negro subjects were all clinic patients. As is usual among negroes of the city, many of them showed indications of more or less white ancestry, a fact which has to be taken into account in any study of American negroes. Both sexes were represented.

The Indians were from several groups. Fifty Shinnecock Indians were examined on the reservation near Southampton, N. Y. These "Indians" have a strong infusion of negro blood and some admixture of white. While they might perhaps be more appropriately classed as negroes, they do show some indications of their Indian ancestry. One hundred and one Penobscot Indians were examined on their reservation near Oldtown, Maine. These Indians probably have no negro blood, but almost all of them have some white ancestry. On

the Indian side several tribes originally more or less distinct are doubtless represented. Only thirteen Indians who appeared and claimed to be of pure blood were examined. Ten of these were Penobscots, one a Seminole, one an Apache and one an Indian of mixed races from Oklahoma. Both sexes were represented in this group.

The Japanese were twenty-five sailors examined aboard a Japanese Cruiser. Unfortunately the presence of the vessel was not

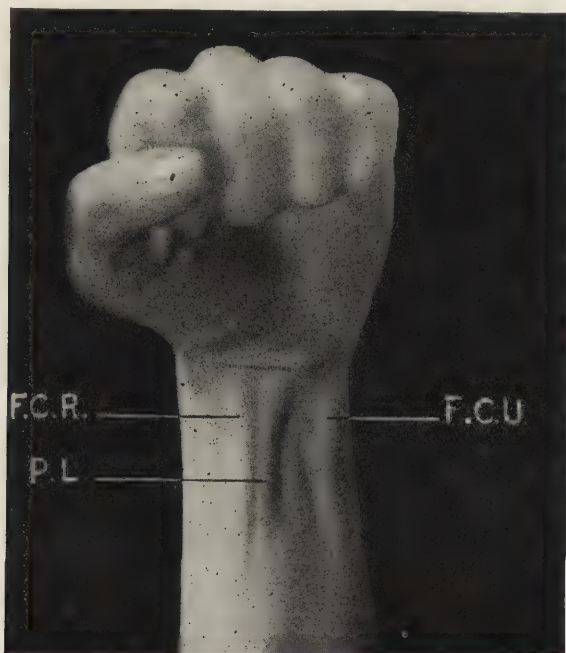


FIGURE 1. Left forearm and hand of a subject showing well developed tendon of the M. palmaris longus. F. C. R., M. flexor carpi radialis; F. C. U., M. flexor carpi ulnaris; P. L., M. palmaris longus

known until shortly before its departure, or a much larger material might have been secured.

The procedure in each case consisted simply of a careful examination of the volar aspect of the forearm and wrist to determine the presence or absence of the tendon of the palmaris longus. When present the tendon was usually conspicuous and easily identified. If not at first apparent it could generally be brought out by requesting the subject to execute a series of movements with the thumb and

fingers, the wrist being held slightly flexed. Flexion of the fingers, individually or together also served to differentiate the tendons of the flexor digitorum sublimis, the only ones that might be confused with that of the palmaris longus. Only when the most careful palpation and all known tests had been applied was the muscle recorded as absent. Figures 1 and 2 represent typical forearms showing presence and absence of the tendon. Both arms were examined in all cases.

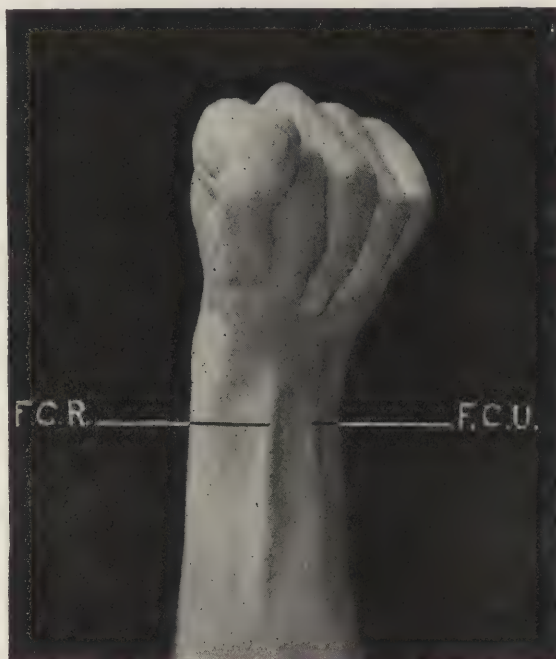


FIGURE 2. Left forearm and hand of a subject lacking the *M. palmaris longus*. Labeling as in Figure 1.

As to the probable accuracy of the records, it can be stated with a good deal of assurance that whenever the diagnosis of presence was made the muscle actually was present. With reference to the diagnosis of absence the situation is less satisfactory. Dissections have revealed, as recorded in the literature, that rarely the muscle is supplied with only a filiform tendon or one which fails to reach the wrist. In such cases the tendon might easily be missed and the muscle erroneously recorded as absent. But such cases are rare and their



influence on the data as a whole must be practically negligible. It is to be understood that this paper is concerned only with presence and absence of a developed palmaris longus tendon, the records, it is believed, may be accepted with about as much confidence as if they had been based on actual dissections.

The danger of selective sampling was kept in mind, although it is difficult to see how in this case such sampling could occur since there is no evidence that variation in the palmaris longus is correlated with any more obvious trait, and neither the subject nor the examiner could tell before hand whether or not the muscle would prove to be present. All examinations were recorded except in a few cases where an arm was found to have been injured or where the subject was so obese as to make a definite diagnosis impossible.

#### DISTRIBUTION OF THE PALMARIS LONGUS IN WHITE SUBJECTS

Group I. The first series of examinations was carried out on 365 men and 401 women. Of the men, 43 were found to lack the muscle in both arms; 17 lacked it on the right side only, and 19 on the left side only. The corresponding figures for the women were 75, 21 and 25 respectively. A more detailed analysis of these figures is set forth in Table I, where it will be seen that the distribution of the muscle with reference to sex and side of the body corresponds fairly closely with the findings of the dissecting room.

Group II. Inasmuch as the families subsequently investigated for data on heredity were selected without previous knowledge of the condition of the muscle in any of the numbers, this group may also be taken as a fairly random sample of the white population, although the fact that the majority of these families were located in a single community may indicate that they represent a somewhat more homogeneous group than the first. In this group there were 220 males and 215 females. Among the males the muscle was absent on both sides in 25 cases, on the right side only in 5 cases, and on the left side only in 5 cases. The corresponding figures for the females were 37, 10 and 11, respectively. These results agree with most of those reported in the literature in that they show the muscle to be more frequently absent in the female than in the male and, in both sexes, somewhat more frequently absent on the left side than on the right.

It is unfortunate for the solution of this problem that many anatomists who have reported variations have regarded the limb and not the individual (cadaver) as the unit. It is consequently frequently

difficult, and sometimes impossible, to know whether the term "subject" refers to an individual or only one of his arms. This point of view has led Le Double ('97)<sup>1</sup> and others to state that the muscle is lacking in a certain percentage of cases, meaning that of all arms dissected it has been found lacking with the frequency indicated, whereas, as clearly pointed out by Schaeffer ('09),<sup>2</sup> the percentage of individuals who lack the muscle on one or both sides is quite a different matter. It is believed that the study of familial manifestations detailed in a subsequent section show clearly that to regard the arms of the same body as independent elements is quite unjustified. It perhaps should be mentioned here that Le Double himself confuses "subject" meaning arm and "subject" meaning cadaver and combines them indiscriminately in his final summary. Moreover, an error in his addition makes a difference of 100 in his total. Consequently instead of his 11.2 per cent of absence, the figures which he employs really give a result which is more nearly 15 per cent. This matter is mentioned only because Le Double's 11.2 per cent has found its way into the text books and is generally accepted as representing the combined result of several investigations.

The method of Le Double does, however, afford a rough index for comparative purposes, and for that reason this percentage has been calculated in each case and is included in the last column of table I. Comparing these percentages with others reported in the literature we have, corresponding to the 15.6 per cent for the males of Groups I and II, 10.7 per cent based on both arms of 350 cadavers studied by Gruber ('79),<sup>3</sup> 19.3 per cent based on 344 arms dissected by Schwalbe and Pfitzner ('94),<sup>4</sup> 13.0 per cent based on both arms of 130 cadavers studied by Le Double ('97),<sup>1</sup> and 22.9 per cent based on Schaeffer's ('09)<sup>2</sup> examination of 375 living males.

The percentages for females are as follows : Group I and II, 23.6 per cent; Gruber's 350 cadavers, 14.7 per cent; Schwalbe and Pfitzner's

<sup>1</sup>LE DOUBLE (A. F.), *Traité des variations du système musculaire de l'homme et de leur signification au point de vue de l'anthropologie zoologique*. 8°, 1897, II., 85-93.

<sup>2</sup>SCHAEFFER (J. PARSONS), On the variations of the palmaris longus muscle. (An Abstract). *Anat. Rec.*, 1909, III., 275-278.

<sup>3</sup>GRUBER (WENZEL), *Beobachtungen aus der menschlichen und vergleichenden Anatomie. Aus der Myologie*, 1879, I., 21-40.

<sup>4</sup>SCHWALBE (G.), & PFITZNER (W.), *Varietäten-Statistik und Anthropologie. Morphol. Arbeit.*, 3° Mitt. 1894, III., 459-490.

176 arms 22.7 per cent; Le Double's 130 cadavers, 21.9 per cent; and Schaeffer's 25 living subjects, 24.0 per cent.

It will be apparent from the two preceding paragraphs that, while in any given group the muscle is absent more often in the female than in the male, the females of one group may have the muscle present more frequently than do the males of another group. This will be apparent on comparison of the results of Gruber with those of Schwalbe and Pfitzner. The rather widely divergent results obtained by different investigators make it difficult, even when all possible allowance is made for differences in sampling and in methods, to escape the conclusion that the "populations" studied have actually varied in the different cases. This point can be discussed more advantageously after the data on heredity and on the distribution of the muscle in the negro have been presented.

With the exception of Schwalbe and Pfitzner, most authors have believed that the muscle is more often absent on the left side than on the right. This is a question that deserves careful study since, if such difference does exist, it is of considerable theoretical interest. Pooling all the data given by Gruber, Le Double, Schaeffer, Schwalbe and Pfitzner, Wood ('68)<sup>1</sup> and the authors it appears that in 2820 right arms and 2826 lefts, there were 495 of the former and 550 of the latter lacking the muscle. The difference is too great to be attributed simply to chance, and would seem to warrant a detailed study of an homogeneous population with reference to sex, age and other factors.

#### THE PALMARIS LONGUS IN THE NEGRO

From the negro and mixed negro patients in the clinic consecutive cases were examined during certain periods each day. This method could not have resulted in any unconscious selection, especially with reference to a trait concerning which nothing could be known till the subject was actually under observation. Three hundred and eighteen cases were examined. (Table I, Group 3). Of the 121 males only 3 lacked the muscle, two on both sides and one on the left. Of the 197 females 15 lacked the muscle, 10 on both sides, 4 on the left only and 1 on the right only. It can not be stated that any of these 18 individuals who lacked the muscle were full-blooded negroes.

<sup>1</sup>WOOD (JOHN), Variations in human myology observed during the winter session of 1867-68 at King's College, London. *Proc. Roy. Soc.*, London, 1868, XVI., 483-525.



A comparison between the records from white and from black subjects, as set forth in table I, can leave little doubt that the tendency of the palmaris longus muscle to be absent shows very definite

TABLE 1.

TABULATION OF DATA FROM THE EXAMINATION OF BOTH ARMS OF 1695 INDIVIDUALS GROUP 1, WHITE STUDENTS AND CLINIC PATIENTS. GROUP 2, WHITE PARENTS AND THEIR CHILDREN. GROUP 3, NEGRO CLINIC PATIENTS. GROUP 4, SHENNECOCK INDIANS. GROUP 5, PENOBSCOT INDIANS. GROUP 6, JAPANESE SAILORS.

Group and Sex	Total number of cases	Present on both sides	Absent on right only	Absent on left sides	Absent on both	Percentage of persons with absence in one or both arms	Percentage of absence in right arms	Percentage of absence in left arms	Percentage of absence in all arms examined
Group 1—Male....	365	286	17	19	43	21.7	16.4	17.0	16.7
Female....	401	280	21	25	75	30.2	23.9	24.9	24.4
Group 2—Male....	220	185	5	5	25	15.9	13.6	13.6	13.6
Female....	215	157	10	11	37	27.0	21.8	22.3	22.1
Groups 1 & 2—Male....	585	471	22	24	68	19.5	15.4	15.7	15.6
Female....	616	437	31	36	112	29.1	23.2	24.0	23.6
Group 3—Male....	121	118	0	1	2	2.5	1.7	2.5	2.1
Female....	197	182	1	4	10	7.6	5.5	7.1	6.3
Group 4—Male....	27	27	0	0	0	0.0	0.0	0.0	0.0
Female....	23	21	0	1	1	8.7	4.3	8.7	6.5
Group 5—Male....	56	43	2	2	9	23.2	19.6	19.6	19.6
Female....	45	33	4	3	5	26.7	20.0	17.8	18.9
Group 6—Male....	25	22	2	1	0	12.0	8.0	4.0	6.0

racial differences. This fact, in addition to revealing one more point of difference between the two races, shows that absence of the muscle in any individual is not wholly a matter of chance.

It is also of interest to note that, so far as the data show, the same relative incidence as to sex and side obtains in both races. The negro seems to differ from the white chiefly in the relative rarity with which the muscle is absent, although the space between this tendon and that of the flexor carpi radialis seems to be characteristically greater in the negro than in the white.

#### THE PALMARIS LONGUS IN INDIANS

All Shinnecock Indians who could be found on the reservation, and who did not object, were examined. Very few showed any reluctance but the numbers were nevertheless small because the reservation was

visited in the summer at a time when most of the inhabitants were away. The same statements apply likewise to the Penobscot Indians. The data from the Shinnecocks are shown in Table I, group 4; those from the Penobscots in Table I, group 5.

As previously stated the Shinnecocks are virtually a tribe of negroes with some Indian and some white blood. The relative constancy of the muscle in this group, small though it is, may probably be attributed to the predominance of negro blood.

Quite different are the results from the Penobscots (group 5). Here the muscle is absent as often as in white subjects studied. In this case there is no negro but some white blood. Since the population here has a predominantly Indian character it does not seem probable that the frequent absence of the muscle is due wholly to mixture with white stock.

It is of great importance for present purposes to have examinations of individuals of pure Indian blood. The only full-blooded Indian found on the Shinnecock Reservation was an Apache who had migrated from Oklahoma. The muscle was present in both of his arms. On the Penobscot Reservation were found four men and six women who claimed to be full-blooded Indians, who appeared to be such, and whose account of their ancestors for several generations seemed to substantiate their claims. In three of the men and three of the women the muscle was present on both sides, in one man and two women it was absent on both sides and in one woman it was absent on the right side only. Two other presumably full-blooded Indian men were met subsequently. One was a Seminole and the other of mixed Indian races. The latter had the muscle bilaterally present. The former was somewhat superstitious and uncooperative but almost certainly lacked the muscle on both sides.

These twelve or thirteen examinations of supposedly pure blooded Indians give nothing of statistical value, but they do make it probable that the muscle is often lacking in the Indian race. Examination of considerable numbers of individuals from western tribes should yield data of much interest.

#### THE PALMARIS LONGUS IN JAPANESE

The meagre data on Japanese are included simply to show that in pure representatives of this race the muscle is sometimes absent. (Table I, group 6). Practically all of these sailors seemed to have the

muscle poorly developed, a condition occasionally met in other groups, especially in individuals lacking the muscle on one side.

#### HEREDITARY CHARACTERISTICS OF THE PALMARIS LONGUS

The hereditary relations were studied in 102 white families. In every case, father, mother, and all the children were examined. Of the 231 children there were 118 males and 113 females. In addition, a few Indian family histories were obtained, some of which are shown in the chart of family histories.

The different types of parental matings and the character of the resulting offspring are summarized in Table II. The first and most striking thing to be noticed in this table is that variations in the muscle are distinctly hereditary. There were 69 families in which both parents had the muscle bilaterally present, and it was bilaterally present in all but one of their 163 children. It may be noted, parenthetically, that the single exceptional individual also differed from the rest of his family in the distribution of hair on his fingers.

There were twelve families in which both parents had the muscle lacking on one or both sides, and every one of their twenty-five children lacked the muscle on one or both sides. So far as the available data go the correlation between parents and offspring was practically complete in the one case and quite so in the other, which may be interpreted to mean that the presence or absence of this muscle is a variation of germinal origin.

In addition to the two groups just mentioned there is another group of 21 families in which one parent had the muscle bilaterally present while the other lacked it on one or both sides. Such parents have produced 43 children of whom 18 have the muscle bilaterally present and 25 lack it on one or both sides. Among these twenty-five children, 13 lack it on both sides and 12 on only one side. Of the 21 families, 5 had only children with the muscle bilaterally present; 10, children all of whom lacked the muscle on one or both sides, and 6 children of both classes.

It might have been expected that the presence of the muscle is occasioned by a dominant gene; but it can be shown by simple calculations based on the laws of probability and chance, that if it were so the 69 families in which the parents had the muscle present should have produced instead of 162 children with the muscle and 1 partially lacking it, 133 children with, and 30 without it. The probability



that it is merely by accident that our data deviate so widely from the hypothetical expectation is remote. This hypothesis must consequently be held in abeyance, at least till more data are available.

The converse proposition, namely that the absence of the muscle

TABLE II. SUMMARY OF DATA RELATING TO THE HEREDITARY ABSENCE OF THE MUSCLES IN WHITE SUBJECTS. EXPLANATION—P STANDS FOR PRESENCE, A FOR ABSENCE OF THE M. PALMARIS LONGUS. IN THE FORMULAE THE SYMBOLS FOR THE RIGHT SIDE PRECEDE THOSE FOR THE LEFT, E. G., PA INDICATES PRESENCE OF THE MUSCLES IN THE RIGHT ARM, ABSENCE IN THE LEFT.

PARENTS		Number of Families	CHILDREN							
Parental Matings			Boys				Girls			
Father	Mother		PP	PA	AP	AA	PP	PA	AP	AA
PP	PP	69	87	0	1	0	75	0	0	0
PP	PA	3	2	0	0	0	1	2	0	0
PP	AP	5	5	0	1	0	1	2	3	2
PP	AA	7	1	0	0	5	1	2	0	4
PA	PP	2	2	1	0	0	4	0	0	0
PA	PA	1	0	0	0	0	0	0	0	1
PA	AA	2	0	1	0	1	0	0	0	4
AP	PP	2	0	0	0	1	0	1	0	0
AP	AA	1	0	0	0	1	0	0	0	1
AA	PP	2	0	0	0	1	1	0	0	0
AA	AP	1	0	0	0	2	0	0	0	0
AA	AA	7	0	0	1	5	0	0	0	8

is a dominant trait also presents itself. The 69 families just mentioned present one exception to the expectations based on such an assumption. Further the 12 families in which both parents lacked the muscle on one or both sides should, on this assumption, have had five or six of the 25 children with the muscle bilaterally present whereas there were none with it bilaterally present and only 2 with it present at all. Nevertheless, there are fewer objections to this hypothesis than to the other. In further support of this view is the fact that of 8 marriages in which one parent had the muscle bilaterally present, the other bilaterally absent, six produced only children with the muscle

absent on both sides. That in many of the families absence of the muscle behaves like a dominant trait—as if due to an inhibiting factor—is indicated by the chart of family histories.

The possibility of multiple factors also suggests itself, but the correlation between parent and child is too close to lend much support to this idea. The statistical distribution of absence of the muscle is not far from what might be expected of a dominant sex-linked trait, but, if it were such, a family in which the father lacks the muscle while the mother has it present should have no sons lacking the muscle. Table II shows that the requirements of this hypothesis are not met. Finally, the possibility that the symmetrical forms represent homozygous conditions while the asymmetrical conditions stand for heterozygosis is not very well borne out by the genetic records.

After many trial groupings of various sorts, it seems clear that complete absence of the muscle, absence on one side, and probably also marked reduction in size of the muscle, a matter which can not be considered in this paper, all belong in one category as contrasted with the bilaterally well developed type in another. The simplest and, on the whole most satisfactory explanation of the heredity seems to be found in the relatively recent conception of *modifying factors* which are agencies indirectly affecting the full manifestation of a character. With this muscle, sex, and even the sides of the body, seems to act as such factors. We would therefore suggest as a tentative hypothesis in explanation of the hereditary relations observed in this study that partial or complete absence of the muscle is due to a single, probably dominant gene, which acts as an inhibitor of its development, but that this inhibition is frequently incomplete because of the action of modifying conditions.

#### SUMMARY

With the data all in hand, the significance of the observations may now be briefly reviewed. Of primary significance would seem to be the fact that absence of the muscle is very strictly an hereditary phenomenon. This must mean that the frequency of its absence in any group depends on the frequency of its absence in the ancestry of that group. Herein, no doubt, lies the explanation of the marked discrepancy between, for example, observations made in St. Petersburg and in Paris.

When whites, as a group, are compared with negroes there is found

to be a marked difference in the absence of the muscle. From the information at hand the possibility can not be ruled out that absence in "negroes" is wholly due to earlier crossing with white blood. On the whole this would seem to be improbable since the other main subdivision of the species, as exemplified by a few Japanese and Indians, shows some absence of the muscle.

The origin of a trait of this sort is a matter of great interest from an evolutionary standpoint. Since it appears from the literature that most of the anthropoid apes occasionally lack the muscle, it is conceivable that its absence has a long heritage in the human species, and that differences between the frequencies of its absence in different races are indicative of diversity of origin. It is much more probable, however, that the mutation, for such it must be, is one of those which are easily induced and which consequently occur with relative frequency in diverse forms. Polydactyly, syndactyly and congenital cataract may be mentioned as traits which we would put in this class. On this assumption we may believe that hereditary absence of the palmaris longus muscle has appeared from time to time, probably in all races, but that the frequency of such occurrence has varied in different races. The negro differs markedly from the white, there is indirect evidence that the different branches of the white race in Europe differ between themselves, and finally there is definite evidence that each individual family, were it not for intermarriage with persons having the other form of the muscle, would perpetuate its own type.

These facts give this muscular variation an important status and show the need, if not of more extensive, at least of more critical data, particularly in relation to different races and homogeneous groups of people. The absence of the muscle presents an especially interesting problem in heredity whenever records of a sufficient number of families with three or more generations of living members can be obtained. From the point of view of ontogeny the relations of associated structures such as nerves, muscles and blood vessels in the presence and absence of the palmaris longus would be of interest; and it is especially important to determine in what way and at what time the influence of sex becomes effective. Whether the palmaris longus is exceptional or its hereditary behavior is characteristic of other variable muscles can not be answered at present, and probably will never be answered except by study of living subjects. There are several muscles that would be favorable for such study.



Briefly to summarize: these studies on the *M. palmaris longus* have

1. Tended to confirm earlier reports as to:
  - a. Frequency of absence of the muscle in white subjects,
  - b. Distribution of absences with reference to sex in white subjects,
  - c. Probable differences between frequency of absence on right and left sides of white subjects;
2. Presented evidence to show that
  - a. Absence of the muscle reveals distinct racial tendencies (at least as between negroes and whites),
  - b. Absence of the muscle is an hereditary trait,
  - c. Discrepancies between results of earlier observers are probably due to racial and hereditary differences in the material upon which they worked.

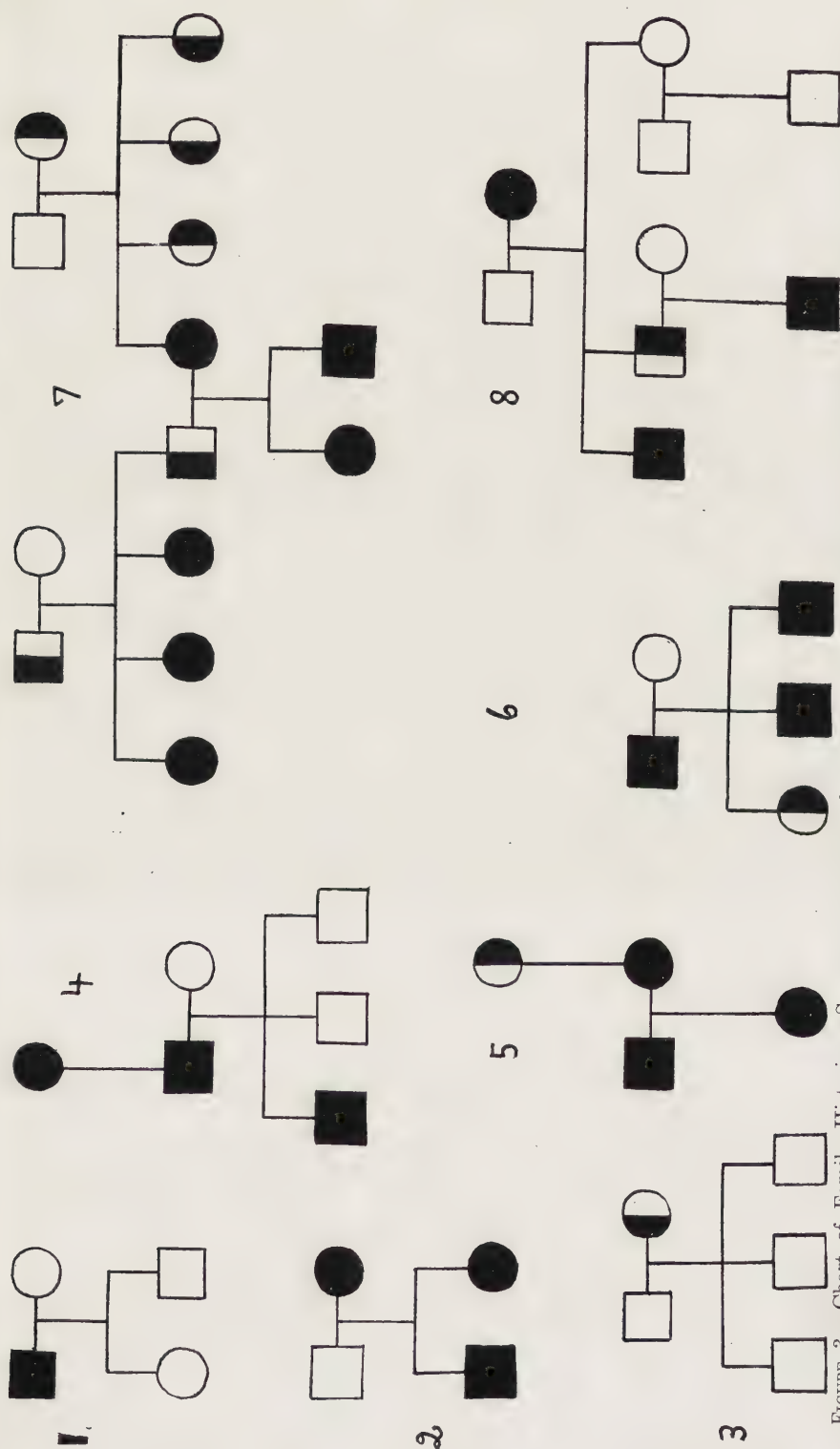


FIGURE 3. Chart of Family Histories. Squares represent males; circles, females. Marriages and children are indicated in the usual way. Unshaded symbols denote presence of the palmaris longus muscle; shaded symbols indicated its absence. The left half of each symbol stands for the left side, the right half for the right side. Families 1 to 5 inclusive are Penobscot Indians, 6 to 8 are white.





## A VARIANT OF THE SINCIPITAL T IN PERU

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A study of primitive and prehistory surgery<sup>1</sup> is a phase of anthropology which furnishes considerable information to our knowledge of Paleopathology. The operations were usually performed to relieve some defect, either traumatic or otherwise, and the surgical results themselves were very often in the nature of severe lesions, the study of which falls within the scope of our subject.

Among several other interesting objects illustrating various phases of Paleopathology, loaned the writer through Dr. L. R. Sullivan by the American Museum of Natural History, is a female skull from Amazonas, Peru, (B. 6684), presumably pre-Columbian, which shows on its vertex the pathology suggested by the title of this paper. It indicates the use of the cautery among the ancient Peruvians, a practice which so far as I can determine, has not hitherto been recorded among the races which inhabited Peru in early times.

We owe to the excellent deductions of Manouvrier,<sup>2</sup> which have been discussed by Sudhoff,<sup>3</sup> and MacCurdy,<sup>4</sup> our first clear interpre-

<sup>1</sup>The writer has contributed several essays on various phases of this subject to the *Surgical Clinics of Chicago*. Attention is called to them here since the serial may not be known to anthropologists, and there is some new material in the papers. The subjects and dates are:

(1). Studies in Paleopathology: Ancient Skull Lesions and the Practice of Trephining in Prehistoric Times. June, 1919, 481-496, figs. 139-149.

(2). Studies in Paleopathology: The Diseases of the Ancient Peruvians, and some Account of Their Surgical Practices. February, 1920, 211-231, figs. 72-83

(3). Primitive Surgery in Ancient Egypt. April, 1920.

(4). The Antiquity of Pott's Disease and other Spinal Lesions; Primitive Treatment. June, 1920.

(5). The Use of the Cautery among Neolithic and Later Primitive Peoples. August, 1920.

<sup>2</sup>L. Manouvrier. 1903. Les marques sincipitales des crânes néolithiques considérées comme reliant la chirurgie classique ancienne à la chirurgie préhistorique. *Bull. et Mém. Soc. Anthropol.* Paris, 5e sér, iv., 494.

<sup>3</sup>SUDHOFF (KARL), 1909 Medizin in der Steinzeit. *Z. f. ärztl. Fortbildung.* 6 Jahrg, No. 6, 196-200.

<sup>4</sup>MACCURDY (G. G.), 1905. Prehistoric Surgery, a Neolithic Survival. *Amer. Anthropol.*, vii, 17-23; pl. 1. Contains a digest of Manouvrier's results with references. Same figure in the two papers.

tation of the curious T-shaped lesions seen on skulls, usually female, of many different periods from the Neolithic down. According to Sudhoff<sup>1</sup> skulls with lesions indicating this procedure are known from northern France (near Mantes, the type locality), Central Asia, Canary Islands, Africa, and I believe we are now able to add Peru. The procedure was used to relieve, as a therapeutic measure, epilepsy or other nervous maladies accompanied by convulsions, and Manouvrier concluded that the operation, which was initiated in Neolithic times, was handed down without change to the surgeons of the Middle Ages. The efficacy of the practice is assured since the most stubborn fit of melancholia would doubtless react violently to the application of boiling oil to a cruciate incision made in the scalp with a rough flint knife. The patient would assuredly take a lively interest in affairs for a time at any rate. It is doubtful if modern surgery has offered a cure for melancholia which is as effective, and certainly none so painful.

The crude incision, the dirty oil and the unwashed skin doubtless always resulted in a severe scalp infection which acted more or less directly upon the subjacent skull and produced lesions of more or less severity. Pathological changes in bone go on very rapidly and we are apprised of this rapidity by Keith's study of bone injuries<sup>2</sup> in the recent war, where it is shown that extensive bone changes and relatively huge osteophytes develop in as short a period as seven weeks. Keith's study enables us to judge, more or less closely, the duration of an infection in an ancient skull from the severity of the lesion.

We are thus within the bounds of experience when we say that the lesions in the ancient Peruvian female skull, though extensive, were not due to an infection of long duration, and possibly the scalp healed after a very few weeks. The lesions take the shape of a cross on the vertex of the skull involving the sagittal and lambdoid sutures. The sagittal incision from the coronal suture back nearly to the foramen magnum has a length of 190 mm. The borders of the transverse lesion are within the limits of the vertex and have a length of 140 mm. The outer table is thickened to 3 mm. The diploe is slightly increased (to 5 mm.) while the inner table is not affected. The vertex is roughened and there are many small separate knob-like growths.

<sup>1</sup>SUDHOFF (KARL), 1908. Le T-sincipital Néolithique etc. *Bull. Soc. franc. d'hist. de la Méd.*, Paris, vii., 175-179.

<sup>2</sup>KEITH (ARTHUR), 1920. Specimens of Long Bones showing the Processes of Infection and Repair. *Brit. J. Surg.*, vii., 302-319, figs. 272-300.

The entire area covered by rugosities has an extent of over 140 sq. cm. The most prominent lesions are the ridges, in the shape of a Latin cross (*crux immissa*), with the longer portion of the upright extending anteriorly on the frontals and parietals, thus forming a variant of the sincipital T, practiced in Neolithic times in France. It would seem, from the pathology, that the scalp had pulled apart at the lines of incisions and in this space had developed a thickening of the outer table, and the adjacent areas had become carious through the agency of the infection which must have been for a time, a violent one.

Microscopic examination of a section of the right parietal ridge shows a tendency for the osseous lamellae to arrange themselves in the form of pseudo-Haversian systems, usually incomplete, being cut off by an invading vascular channel. The lacunae are all provided with an abundance of canaliculi which anastomose in the deeper layers. As one approaches the surface layers anastomosis disappears, the lacunae become irregular in shape, often rounded, and the canaliculi are irregular and distorted.

The lesions are evidently due to a scalp infection, and the form which the lesions take have suggested to me the possibility of offering the above explanation. It is no new thing to find expressions of primitive ideas in widely separated regions since the practice of trephining was common in France and in Peru. The idea will, of course require confirmation from other observations since a deduction founded on a single occurrence is not conclusive. The interpretation is, however, offered as an explanation of the pathology of the pre-Columbian female skull from Peru.

PLATE I. Skull of a female Peruvian Indian of supposedly Pre-Columbian age, from Amazonas, Peru. The vertex shows the large cruciate ridge, shown diagrammatically in the small upper left-hand figure, due possibly to a scalp incision for the purpose of using the cauterizing substance or it may have been done by the actual cautery. At any rate the lesions on the skull are evidently the result of a severe scalp infection which may have been due to the cautery. The regular cross-shaped lesion cannot be interpreted as accidental injury but bears all the evidences of design, and it may be regarded as related to the Sincipital-T described by Manouvrier from the Neolithic tumuli of France. Other evidence will be needed to substantiate this interpretation.

The small figure in the lower right-hand corner shows a section, enlarged four diameters, taken through the ridge on the right parietal showing the hypertrophy of the outer table, which is very compact and filled with partially developed Haversian systems, the diploe slightly enlarged and the inner table little changed.

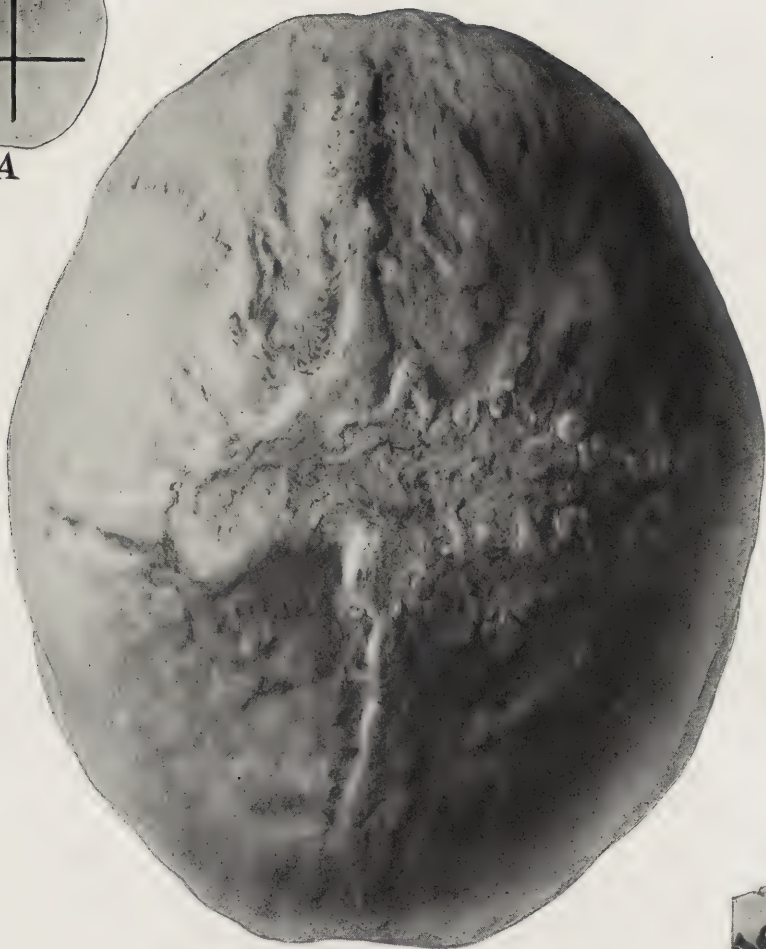


PLATE II, FIGURE 1. Lateral view of the female skull from Peru. The results of cauterization may be seen in the undulating surface of the occiput, the roughened aspect of the right parietal and in the sagittal ridge.

FIGURE 2. Occipital view giving some idea of the great extent posteriorly of the lesions, well shown in Plate I. The height of the anterior sagittal ridge is clearly shown. This is continued across the inion as a posterior ridge. The skull had lain for years partially embedded in soil, but there is no apparent surface change in the bone due to weathering. Immediately to the right of the inion a small section was taken out for microscopic examination. The opening, being filled with plaster appears more smooth than its adjoining territory. It is also somewhat darker. The drawing, Plate I, was made before the material for sectioning was removed. Careful microscopic examination of the sections made shows no effects due to weathering. The photographs are untouched.



A



B

PLATE I.



PLATE II.



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## THE TESTING OF PHYSICAL EFFICIENCY

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The sequellae of the great War have set many a task to the medical and anthropological sciences, and one of the most urgent of these is how to determine in the best way the physical efficiency of a given person. In a preliminary way the writer has dealt with this problem before the International Institute of Anthropology, Paris, 1920, and in the present paper will endeavor to describe his methods as far as developed.

The indications are, it may be said at once, that it will be necessary, besides employing a general procedure capable of giving us a good estimate of the physical efficiency of any subject presented for examination, to use also modified methods for testing men of different vocations, similarly as is done by psychologists in the testing of mental qualities.

The methods to be described here may be termed "somatotechnic," in harmony with the term "psychotechnic" usually adopted for similar procedures in psychology.

It is plain that the anthropological measurements usually employed are not sufficient for the purpose in view. Also it would not be advisable to put too great a weight on any single anthropological character. For instance, an above-the-average stature is not always an indication of physical superiority, but may be connected with delicate muscles, and a considerable weight of body might indicate an unhealthy obesity. Even a combination of several anthropological characteristics does not always help much as for instance in the case of the *Index ponderalis*.

In estimating a person's physical efficiency it is necessary to take into consideration, aside of his general physical characteristics, also the respective organs and tissues connected with muscular work. For this purpose it seems advisable to proceed in the following way: (1) To determine anthropometrically the extent of the different tissues, especially bones, muscles and skin with the subcutaneous fat; (2) to determine by physiological methods the qualities of the principal organs, such as muscles (reaction to impulses, fatigability etc.), lungs, the vascular system, etc.; and (3) to determine, by careful medical examination the state of health with possible serious hereditary defects and other pathologic factors of the body. And it is desirable to express the state or grade of physical efficiency by as far as possible a simple formula.

So far as the development of the body is concerned (skeleton, muscles and fat), the author makes use chiefly of the dimensions of the extremities, which are easy of access and represent essentially organs of physical work, similarly as the brain represents essentially mentality. The mutual relation of the tissues in the body, we may assume, is and changes substantially the same as in the extremities. The osseous parts of the extremities give us a good idea of the skeleton as a whole. The development of the skeleton therefore is estimated from the thickness of the bones of the extremities, measured where they are easy of access, and in relation to the stature. The writer measures the maximum transversal dimension of the lower end a.) of the humerus, b.) of the forearm, c.) of the thigh bone, and d.) of the leg; in other words the transverse diameter of the humeral and femoral condyles and of the wrists and ankles. The condylar measurements for greater accuracy are taken on the bent extremities; and the squared average of the four dimensions— $o$  (ossa)<sup>2</sup>—multiplied by stature in centimeters— $L$  (Length), gives a value representing the weight of the skeleton ( $O$ =skeleton). The coefficient  $k_1$  which there are reasons to believe amounts from 1.0 to 1.2 (still to be tested on corpses) will equalize all arisen errors. The formula then reads thus:  $O = o^2 \times L \times k_1$ . The procedure is not an arbitrary one, but based on due considerations. A young man of 180 cm. height and 72.5 kg. weight, gave respectively 73, 55, 105 and 78 for the four dimensions on the limbs, which gave the average of 78 mm. or 7.8 cm. The square of this (60.84 cm.<sup>2</sup>) multiplied by the stature and by the coefficient 1.2, gave as the representation of the weight of the whole skeleton 13,141 gr. i. e. 18.1% of the weight of the whole body.

For the estimate of the quantity of the skin and of the subcutaneous fat, the writer uses the thickness of the skin fold on the upper arm,

above the biceps; on the forearm, on the plantar side where the maximum breadth of the forearm occurs; on the thigh halfway between the inguinal fold and the knee, above the quadriceps muscle; on the calf of the leg; on the thorax half way between the nipples and the umbilicus (on the costal margin); and on the abdomen half way between the navel and the anterior superior iliac spine. These dimensions are secured by a sliding compass with blunt points,<sup>1</sup> with the exertion of a mild pressure just to enable the skin fold to slip out of the branches when the fingers don't hold it any longer. One half of the average of these several dimensions gives the thickness of the skin together with the subcutaneous fat ( $d$ ) and by multiplying this with a value representing the surface<sup>2</sup> of the body ( $S$ ) and a coefficient  $k_2$ , the total quantity of the skin and of the body fat ( $D$ ) is obtained according to the formula:  $D = d \times S \times k_2$ . Presumably again the fat of the viscera undergoes the same changes in the various stages of health as the subcutaneous fat. In the above-named young man the surface areas was, 21,407 cm.<sup>2</sup>; and the average thickness of the skin fold, 8.17 mm., the half of this 4,085 mm. Taking the coefficient  $k_2$  as 0.13, the result for the weight of the skin inclusive of the fat will be:  $21,407 \times 4,085 \times 0.13 = 11,338.19$  gr., or 15.6% of the weight of the body.

For the estimation of the quantity of muscles ( $M$ ) one of the following formulae might be used:  $M = k_3 \times r^2 \times L$ , or  $M = k_4 \times c^2 \times L$ ;  $k_3$  and  $k_4$  being assumed coefficients (to be more exactly determined on corpses),

<sup>1</sup> The sliding compass adjusted in this way has been manufactured by Brothers Cízek, Prague, Czechoslovak Republic.

<sup>2</sup> For the calculation of the surface of the body there were several methods recommended; the most simple is the one of *Vierordt-Meehe*:  $S = 12,312 \sqrt[3]{P}$ , who takes only the weight of the body ( $P$ ) in consideration and therefore it is least reliable. A more thorough method is the one adopted by *Miva-Stölzner*:

$$S = 4,5335 \sqrt[6]{P^4 \times L^4 \times Ct^2} \text{ in which there are not only the length of the body (L)}$$

Ct P L

but also the circumference of the thorax (Ct) taken in calculation. A still more accurate method seems to be the one of *Du-Bois-Delafield*:  $S = P \times L \times 71.84$ , and

of *Bouchard*, for lean bodies:  $S = 0.45 \frac{Ca}{Ca} L + 7.70 \frac{P}{3.14L} + 3.31 L \sqrt{\frac{P}{3.14L}}$ , for stout bodies:

$$S = 0.46 \frac{Ca}{Ca} L + 7.84 \frac{P}{3.14L} + 3.33 L \sqrt{\frac{P}{3.14L}}, \text{ which prefer the circumference of the}$$

waist (Ca).



$r$  and  $c$  respectively the average radius and the average circumference of the extremities without skin and without subcutaneous fat, and  $L$  the stature. The circumferences are taken, on the arm above the venter of the biceps with the arm flexed without any exertion of strain; on the forearm the maximum; on the thigh half way between the trochanter and the lateral epicondyle; and on the leg the maximum circumference of the calf. These dimensions serve for the calculation of the mean circumference and of the mean radius (circumference =  $2r$ ), from which is subtracted the thickness of the skin and of the subcutaneous tissue of the respective parts obtained by the method described above). The square of the radius of the "muscular column" thus obtained (including of course the osseous nucleus), multiplied by the respective stature and coefficient, gives a value which may be taken as representing the total quantity of the muscles. In the above mentioned young subject the figures were as follows: The mean circumference 35,825 cm., hence the radius 57 mm.; thickness of skin 3.88 mm.; the radius of the "muscular column" is then  $57 - 3.88 = 53.12$  mm. The respective coefficient appears to be about 6.5 and thus we get the following formula:  $M = 5,312^2 \times 180 \times 6.5 = 33,072.77$  gr., or approximately 45.5% of the whole weight of the body. Calculating in this way it is of course assumed that the development of the muscles and the skeleton is mutual and corresponding; it would require a more complicated formula to take a special consideration of the development of the skeleton, such as for instance  $M = (k_5 r^2 L) - k_6 O$ .

Investigations on corpses for the purpose of obtaining the accurate coefficients are still lacking, but preliminary calculations give us confidence that the method employed here is fairly suitable for the purpose for which it has been designed. The writer used it on twelve boys of 16-17 years of age, apprentices of different trades (3 blacksmiths, 6 butchers and 3 barbers), all in good state of health, with the following results:

	Stature cm.	Circum- ference of Thorax cm.	Weight of Body kg.	Estimated Weight of			Dynamometric Effect lbs. Eng.
				Skeleton gr.	Muscles gr.	Skin & Fat gr.	
Minimum.....	157	80.0	47.8	8,206	19,407	8,763	219
Maximum.....	181.5	91.5	74.7	14,169	33,073	16,793	404
Average.....	166.9	85.5	57.3	10,389	24,492	10,889	309

The last column in the above table adds to the data on bodily development a figure showing in a general way the physiological efficiency

of the muscles. This figure is the sum of the dynamometric measurements of the pressure with the right and left hand together with pressure and tension with both hands together, and is expressed in English pounds. The next table gives the results by the trades, and shows that the apprentices of butchers and blacksmiths have certainly on an average a heavier skeleton and a greater quantity of muscles than those of barbers:

Apprentices	Stature cm.	Circum- ference of Thorax cm.	Weight of Body kg.	Estimated Weight of			Dynamometric Effect lbs. Eng.
				Skeleton gr.	Muscles gr.	Skin & Fat gr.	
3 barbers . . . . .	165.5	81.8	51.2	9,823	21,374	9,987	241
3 blacksmiths . . . .	169	84.7	58.7	10,167	25,382	10,476	311
6 butchers . . . . .	166.6	87.9	59.7	10,783	25,607	11,545	343

The figures are by no means perfect, but give a good idea of how the method works.

In the course of the tests there was visible a distinct relation between the quantity of the muscles and the dynamometric effect, so that it was possible to come to the deduction that a quantity of muscles amounting to 25 kg. corresponds to about 300 lbs. of dynamometric strength; a quantity of more than 27 kg. answers to about 350 lbs.; a mass under 23 kg. to about 250 lbs. The dynamometric record does not always correspond exactly or even very closely to the quantity of muscles, for outside of other possible reasons the muscular strength of the hands as tested by the dynamometer is not a perfect expression of the efficiency of the whole body—there may be a disproportionate development of different groups of muscles. This has been shown strikingly in the tests of three teachers of gymnastics. The records in these cases were:

	Stature cm.	Circum- ference of Thorax cm.	Weight of Body kg.	Estimated Weight of			Dynamometric Effect lbs. Eng.
				Skeleton gr.	Muscles gr.	Skin & Fat gr.	
D. V. . . . .	169.3	92.7	72.0	13,045	34,566	9,459	567
A. J. . . . .	171.1	92.1	72.5	11,396	38,462	7,305	463
F. J. . . . .	163.7	94.7	62.0	10,042	32,363	6,188	436

The first man, D. V., shows by far the highest dynamometric strength, whereas A. J. gives the highest figure for the quantity of muscles. This discrepancy is accounted for by the fact that A. J. had recently a bilateral affection of the scapular muscles and evidently cannot yet handle

the dynamometer with the expected muscular strength. Besides this there is an excessive development of the thoracobrachial muscles in D. V., whereas A. J. has especially developed the antebrachial and tibial muscles. The circumference of the arm above the deltoid and close to the insertion of the pectoral muscle in maximum extension of the arms (as in measuring the span), was, in D. V., 38.2 cm., in A. J., 34.7 cm., and in F. J., 35.3 cm.

A sufficient number of investigations in this line shall furnish us with accurate data which when properly arranged will constitute a good basis for comparisons and enable us to determine almost at a glance whether a given person has or has not according to his age, sex etc. an average skeleton, medium, feeble or bulky muscles, insufficient, normal or excessive quantity of fat.

With regard to the aforesaid it is of interest to compare the respective figures of a very emaciated woman of 52 years of age with those of a woman of 30 with general obesity.

Stature cm.	Circum- ference of Thorax cm.	Weight of Body kg.	Estimated Weight of			Dynamometric Effect lbs. Eng.
			Skeleton gr.	Muscles gr.	Skin & Fat gr.	
160.2	79.5	39.5	8,404	12,726	2,738	113
158	119.0	90.0	8,072	18,798	47,685	211

The value for the skeleton in both women, it is seen, is about the same, but that for the quantity of muscles is in the first one considerably lessened, to which answers a diminished dynamometric effect. The greatest discrepancy is of course in the quantity of adipose tissue; in the emaciated woman the figure runs only to about 2.75 kg. of fat, whereas in the stout one it rises to more than 45 kg., i. e. just about half of the whole weight of her body. The whole weight of the body in the second woman of 30 years was 90 kg.; if we subtract from this the quantity of *excessive* fat, amounting to about 37 kg., we then get a normal weight of the body, with which the estimated quantity of bones and muscles as well as the dynamometric effect should really be compared.

The relative proportion of the figures for the weight of the skeleton, the muscles and the fat, gives us a basis for the control of our results. This control is possible if we assume that the weight of the intestines, brain and blood is varying but little; for the purpose the following



formula has been used:  $P - Pk = O + M + D$ . For illustration we may take the case of the young man mentioned first in this paper; the corresponding figures for him are:  $72.5 - (72.5 \times 0.206) = 13,141 + 33,073 + 11,338$ . The coefficient  $K_7 = 0.206$  is again but approximate and has to be verified on corpses. If the dimensions of the head and stature allow an estimate of the weight of the brain and intestines ( $J$ ), then we get the following formula:  $P - Pk_8 = O + M + D + J$ .

The comparison of the estimates of the different parts of the body here dealt with gives us a good idea of their mutual relation. The proportionate development of the skeleton, as passive part, and especially that of the muscles, as active part of the motor apparatus, is of much importance for the estimate of physical efficiency. But the estimate of the adipose tissue is also of value in view of the importance of this tissue in the economy of the body.

The proportional figures representing the numerical values of the different systems or parts may be calculated in per cent of the whole weight of body, the last one being taken as 100. The data obtained thus are seen in the following table:

	PERCENTAGE OF			
	Skeleton	Muscles	Skin and Fat	Remainder of Body
12 Apprentices Average.....	18.1	42.7	18.9	20.3
Range of Variation.....	14.4-21.1	39.9-50.0	15.1-23.0	15.2-23.7
D. V., Gymnast.....	18.1	48.0	13.1	20.8
Woman, 52 yrs., emaciated....	21.3	32.2	6.9	39.5
Woman, 30 yrs., fat.....	9.0	20.9	52.9	17.2

These data nevertheless have to be considered with some discreetness. A better base for comparison is offered by the weight of the skeleton which, except in old age, is but little liable to changes. Using the weight of the skeleton as 100 the data appear as follows:

	Weight of Skeleton = 100	
	Percentage of Muscles	Skin and Fat
12 Apprentices, Average.....	235.8	104.8
Range of Variation.....	192.7-283.3	85.3-146.9
D. V., Gymnast.....	265.0	75.5
Emaciated Woman.....	151.4	32.6
Fat Woman.....	232.8	590.7

The writer is well aware of the fact that the methods set forth in this paper have their deficiencies and that the diverse coefficients will

have to be calculated very carefully with regard to sex, age, stature etc. with due control on corpses.<sup>1</sup> He is well aware also that the qualities of the different tissues also demand consideration, as well as the results of other physiological tests. It will be desirable, for instance, to ascertain the quantity of the inspired air in relation to the weight of body and especially in relation to the quantity of muscles; but such details cannot be discussed at the present moment, they need considerable further study. For the present another important factor also has been omitted, namely the mental influence on muscular work; in other words we have not taken into consideration in connection with the tests of strength, the influence of exercise, training, experience and the mental tone of the subject at the time of the tests; this also must be reserved for future determination.

The method of ascertaining physical efficiency as here approached, has for its purpose the possibility of a completion of the psychotechnical examination, so that we may get a fuller insight into the physical and mental efficiency of any given individual, and will be useful or called upon in Life Insurance examinations, in Colleges and Sanatoria, before a definitive choice of a profession, trade, line of sport, wherever a particular efficiency is required, and on other occasions.

The method will doubtless have to be perfected and differentiated to meet different wants, but the writer feels convinced that the measurements and determinations of physical anthropology—alone or in connection with psychology—will in future prove of considerable industrial and social utility.

<sup>1</sup> In calculating the coefficients the writer profited by data found in the literature for the weight of different organs and systems of organs. According to *Vierordt* (Anat. Daten und Tabellen, 3rd ed. 1906, p. 44) the coefficients for adult persons would be:  $k_1=1.15$ ,  $k_2=1.22$ ,  $k_3=6.6$ ; the first figure and the second one seems to be a little bit too low, the last one was just a little too high.

## LENGTH AND WEIGHT

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### SYNOPSIS OF SIMILAR STUDIES

Methods for predicting the normal weight for a given person from one or more of his physical measurements have been proposed from time to time, but have surprisingly seldom been tested simultaneously on the same series of healthy individuals. Even a brief test will reveal astoundingly diverse predicted weights for the one and the same subject, according to the formula applied. The conclusion seemed fair therefore that more study was necessary to determine which of these competing "standards" was most worthy of the name.

The procedure chosen to test existing weight standards was simple though tedious. It has been described elsewhere in detail. In brief, we applied a given standard to a given case, then took the difference between this theoretical weight and the subject's actual weight (which last was assumed to be the correct basis), and translated this difference in pounds from the observed weight into a percentage deviation or error. The formula was  $\frac{(PW - W) \times 100}{W}$ . For instance, if the predicted weight was 120 lbs. and the weight 100 lbs., the difference of 20 lbs. was recorded as a 20% prediction error. By summing the errors thus calculated, and dividing through by the number of subjects measured we secured the average error of the prediction standard A. Standards B, C, etc. were similarly tested in turn.

In 1917 twenty healthy and active male medical students, aged 22-34 years, were weighed and measured and their weights predicted by the following formulae:

<i>U. S. Army:</i>	H. 64 inches	average W. 128 lbs.	H. 69	W. 148
	65	130	70	155
	66	132	71	162
	67	134	72	169
	68	141	73	176



<i>Bornhardt's:</i>	$W \text{ (in k.)} = H \text{ (in cm.)} \times \text{Chest-girth (in cm.)} \div 240.$
<i>Broca's:</i>	$W \text{ (in k.)} = H \text{ (in cm.)} \text{ minus } 100.$
<i>Guthrie's:</i>	$W \text{ (in lbs.)} = 110 + (5.5 \times \text{number of inches of } H \text{ above } 60).$
<i>Medico-Actuarial:</i>	This American insurance table is too long to quote here.
<i>Von Noorden's:</i>	$W \text{ (in k.)} = H \text{ (in cm.)} \times 0.455.$

The relative accuracy of these six methods for estimating normal weight was found to be as follows:

1. Bornhardt's:	5.5% error	4. Guthrie's:	9.5
2. U. S. Army:	7.33	5. Broca's:	13.1
3. Medico-Actuarial:	7.35	6. Von Noorden's:	19.7

In 1920 the theory and practice of our trial-technic were discussed in greater detail, and the evidence enlarged by the addition of data on 229 U. S. soldiers, aged 18-34; who had been active in service and under our observation for a number of months. These results confirmed the preliminary series, and the consolidated 249 subjects showed the following mean errors in prediction by the several standards:

1. Bornhardt's:	6.0%	4. Guthrie's:	11.5
2. Army:	8.3	5. Broca's:	14.6
3. Insurance:	8.6	6. Von Noorden's:	23.4

Further analysis of the data obtained by Bornhardt's method showed no material variation in accuracy at varying ages, weights, heights and chest-girths.

Finally the conclusion was offered that just as Bornhardt's rule (based on height and chest-girth) as a rough measure of surface seems both theoretically and empirically the best guide so far offered for guessing weight, so we expected that experiment would discover an even better rule (based on height, chest and a third factor) expressing a rough measure of volume. For fundamentally weight must be proportional, not to length nor surface, but to cubic mass.

In March 1921 were published the results of experimental efforts to improve Bornhardt's rule by altering it in ten different ways. For example, it was made an expression of cubic contents instead of surface by multiplying the height by the *square* of the chest circumference, and by multiplying the chest by the square of the height. These efforts were fruitless.

Next, in April 1921, were published extensive historical and theoretical considerations of the "essential stature" (stem-length or trunk-length) as a substitute for the full stature, and actual new observations

along this line<sup>1</sup> were presented in June 1921. In the latter article were examined two of the most promising of these tables of weight in reference to the essential height, namely those given in the recently available books by Von Pirquet and by Dreyer and Hanson. It was found that the weights of thirty-two healthy males, aged 13 to 52 years, were predicted with the following errors, according to: 1. Dreyer and Hanson: 4.47%; 2. Bornhardt: 8.0%; 3. Von Pirquet: 17.0%.

#### OEDER'S UPPER LENGTH AND WEIGHT FORMULA

Oeder in 1908 stated that he had been searching for a weight formula during the past twenty-four years of study of 23,400 patients.

In 1909 and 1915 he reported observations on the relation of weight to what he called the Proportional-Length (PL), which was twice the "Oberlänge," i. e. the distance from the vertex to the theoretical center of the symphysis.

The landmark for this measurement he took as the upper edge of the symphysis as found by palpation, and to this measurement he added two centimeters, which he had estimated to be half the usual vertical thickness of the bone. The result which may be translated as Upper Length, and which we shall abbreviate as UL, he believed to be not more than one centimeter in possible error, and this error he regarded as of no account.

He then modified Broca's simple and much used formula,  $W$  (in k.) =  $H$  (in cm.) minus 100, by substituting for the Height the Proportional Length ( $2 \times UL$ ), thus:  $W$  (in k.) =  $PL$  (in cm.) minus 100.

As male *subjects* for study he used patients who came to him, whether under or overweight, generally the latter; and used only those whose growth he considered complete, namely those at least 24 years old and 135 cm. tall. After measuring them he predicted by his formula what their weights should be when they should have been treated till in a "normal state of nutrition."

The *signs of the normal state of nutrition* he laid down as follows:

1. Invisibility of the intercostal spaces near the sternum; 2. Invisibility of the intertendon spaces on the backs of the hands; 3. Equal level of abdomen and chest when supine; 4. Abdominal fat layer of 2 to 3 cm. as measured (to nearest half centimeter) with calipers, at the base of a fold picked up just to the right of the navel (Indexstelle, Vergleichsstelle). For this "Fettpolstermessung" he found nearly the

<sup>1</sup> In print.

same figures (2-3 cm., average for men 2.5 cm., for women 2.7 cm.) in normals of both sexes and all adult ages (men 24 and over, women 21 and over). While granting that the distribution of the fatty layer varies slightly in the sexes and at different ages, he found the variation so small that "the normal state of nutrition can generally be defined fairly accurately for any subject by the same measurement, the Index-fettpolsterdicke alone."

The nutrition he would often consider normal, even in the absence of one or the other of these signs, most frequently number 2.

When these "central-normal-inspection-signs" seemed to him to indicate that normal nutrition had been reached, he recorded the patient's weight as the "central-normal-weight" and compared this actual weight (Istgewicht) both with the predicted weight according to Broca's formula and with the predicted weight according to his own (Formelgewicht). He concluded that Broca's gave a greater error than his own, which he maintained to "hold true in 97% of men."

#### CRITICISM BASED ON THEORY

In principle, Oeder's measurement from vertex to midsymphysis ("Oberlänge") may be presumed to be most nearly comparable to the dorsal measurement from vertex to tip of coccyx, i. e. the "Stamm-länge II" advocated by Dreike 1895 and others whose work has been reviewed in our earlier paper. This measurement however we have not recorded, and can therefore make no exact comparison.

The only dorsal measurement which we have noted is the stem-length, and to this too Oeder's measurement bears a close relation, and like it might be expected to afford a basis for a weight-for-"length" formula more accurate than the time-honored weight-for-stature formulae.

The only writers who have discussed the utility of Oeder's formula so far as we know are Zickgraf 1912 and Brugsch 1920. The former is mentioned by Oeder as having given support, but we have not found that writer in the place to which Oeder refers. Brugsch recognized that some value in rendering medical judgment more objective may lie in Oeder's criteria of the normal state of nutrition, but he disputed the contention that patients who exhibit these criteria are to be considered as necessarily having normal weights. He asserted rather that "normal weight is average weight," that Oeder's subjects were not normals but mostly overfed adults of middle age, and that therefore his formula made young adults seem too lean.



For our part, while granting, as said above, certain interesting principles in Oeder's work, we also feel certain doubts as to the methods he used in developing these concepts:

1. We question, like Brugsch, the propriety of accepting as normals subjects admittedly abnormal at the start, and only presumptively rendered approximately normal.

2. This limited class of persons was further limited, as Oeder admitted, by considering only the *central* normals, i. e. those approaching neither upper nor lower borders, but "in approximately complete normality." This restriction is open to argument in view of the repeated evidence in the literature that the normal average is *not* a central figure (or curve), but that at the most the average is a dominant lying within a normal zone.

3. Oeder juggled the Oberlänge by adding or subtracting anywhere from 2 to 3.5 cm. to the measurement noted on subjects who seemed to him to have short or long necks. This procedure resembles that of artists such as Alberti ca. 1400, Leonardo da Vinci and Dürer ca. 1500, and even Schadow ca. 1800, who measured such individuals or classical statues as appealed to their ideals of beautiful proportions, and then constructed arbitrary "canons."

4. Oeder's method of assembling his numerical data seems erroneous from the viewpoint of statistics. For he added the actual weights of all his subjects, and again all the predicted weights, took the difference of these two sums and divided that difference by the number of subjects. The resulting average was incredibly small, but is devoid, we believe, of all value biometrically. For by adding the predicted weights directly, those which were too high balanced those which were too low, and so yielded a fictitious semblance of accuracy. This method may mask, for example, such a reduction ad absurdum as the following:

If in his case 1 his Formula-weight was 10 k. *above* the actual weight (and this may have been the fact for all we can tell from his article), while if for his case 2 the Formula-weight was 10 k. *below* the observed weight; and if in case 3 the predicted weight was 20 k. too high while in case 4 it was 20 k. too low; and so forth down the list; yet at the bottom of the columns the sum of these wild predictions would still equal the sum of the "Istgewichte" and the formula would apparently be perfect!

5. The categorical insistence that his figures "zwingen absolut," while complaining that nobody seems to believe him.

6. Definite location of the landmark is difficult in even moderately fat persons, painful in the fat, and incidentally sufficiently objectionable on grounds of delicacy to restrict its application in women.

#### CRITICISM BASED ON FACT

To test Oeder's work an unusual measurement is required. This we had not noted at the time of our preceding paper, but have since been able to record on twelve of the persons there studied. Despite this small number of observations, their indications seem so uniform that they seem worth reporting in Table I, as a guide for any further work with this measurement, either in reference to weight-prediction, or in reference to the abnormal endocrine ratio between the upper length and the stature.

UPPER-LENGTH AND PREDICTED WEIGHT

Case	UL Upper-Length Vertex-Midsymphysis			PL (2×UL)	PW (Oeder)	E %	PW (Broca)	E %
	Direct Meas.	Indirect Meas.	Mean		k		k	
H. G. ....	91	92	91.5	183	83	+ 8	81	+ 5
A. M. W. ....	94	93	93.5	187	87	0	86	- 1
D. T. V. ....	89.5	88	88.8	178	78	+11	77	+10
W. R. ....	95	94.5	94.8	190	90	+ 6	89	+ 5
E. B. B. ....	87	87	87	174	74	+17	79	+24
F. G. B. ....	86.5	87.5	87	174	74	+ 8	78	+13
F. G. T. ....	87	86	86.5	173	73	+15	71	+11
H. F. R. ....	88	90	89	178	78	+13	75	+ 9
H. B. W. ....	88.5	87.5	88	176	76	+23	75	+21
J. C. W. ....	89.5	88.5	89	178	78	+10	84	+18
E. H. C. ....	86	86	86	172	72	+ 3	73	+ 4
A. A. H. ....	89	88	88.5	177	77	+13	71	+ -4
Sum. ....						127		125
Mean. ....						10.6%		10.4%

*Explanation of the column headings in the Table:* The term Upper Length is a literal translation of Oeder's Oberlänge, and has been here abbreviated as UL. He does not state the position of his subjects during mensuration nor whether his measurement was direct or indirect. Direct measurement of the UL was made by us with the subject recumbent on a table, with the vertex against a wall, and the head so placed that the eyes looked straight up at the ceiling, or in more specific anatomical words so that an imaginary line from the lower edge of the orbit to the external auditory meatus was vertical to the table. The legs lay flat. The cephalad edge of the symphysis was palpated and a mark made on the skin. A tape was stretched from this mark to the wall, and to the distance read off were added 2

cm., following Oeder's rule, to get the UL or distance vertex-midsymphysis. Indirect measurement of the UL was obtained by subtracting from the stature the Unterlänge, or distance midsymphysis to soles. To take this lower length, the subject, without shoes, stood heels together against a wall instead of lying down, the tape was dropped from the mark at the top of the symphysis, the distance to the floor between the feet was read off and two centimeters were deducted.

*Interpretation of the data in Table I* is offered as follows:

The reliability of Oeder's measurement, merely as to technique (quite apart from the value of the derived formula), is seen by comparing the direct with the indirect columns. There the value is seen to vary by as much as 2 cm. or on the average by one centimeter. This confirms Oeder's view of the size of the technical error. Besides varying in size, the error varies in direction, that is, the indirect measurement was equal to the direct in 2 cases, larger in 3 cases, and smaller in 7 cases. Judging by this majority of seven, the tendency seems to be for the subject when standing to stretch out the lumbar spine more than when recumbent with legs flat, and thus to tilt the symphysis upward and yield a shorter upper length.

The importance of this error is very likely as Oeder maintained, "of no account," as regards his formula. At the same time a more constant measurement would be desirable if feasible, and one such feasible method would be to make a practice of (1) taking upper length directly, and (2) putting the subject in a constant position, preferably flat on his back with knees bent up and dorso-lumbar spine relaxed sufficiently to obliterate the lumbar curve so that the observer's hand cannot be slipped between the subject's back and the table. This change in position tips the pubis toward the head and so shortens the direct measurement, in fact by about four per cent in a few observations not here listed. This divergence we believe to be worth avoiding. Whether it be preferable to record the distance vertex-mid-symphysis with the spine flexed or flattened is open to argument. The latter position we find to yield more constant duplicates (at least on the few persons observed), and therefore believe it to be preferable.

The direction of the error in Oeder's formula seems to be constantly high; or, as Brugsch has put it, makes young adults seem too lean.

The accuracy of weight-prediction by Oeder's formula, as tested on our normal young adults is seen (from the Table here, from Table 3 of our earlier paper, and from untabulated calculations from applying the insurance figures to these test cases) to be unsatisfactory.



A summary of the percentage prediction error by the different methods discussed in the preceding paper and here, is given below listing first the weight-prediction standard which guessed nearest to fact:

PREDICTION ERROR, STATED AS MEAN PER CENT DEVIATION FROM ACTUAL WEIGHT

1. Dreyer and Hanson.....	3.9	4. Broca.....	10.4
2. Bornhardt.....	6.4	5. Oeder.....	10.6
3. Medico-Actuarial.....	7.9	6. Von Pirquet.....	14.5

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# THE QUANTITATIVE DETERMINATION OF BLACK PIGMENTATION IN THE SKIN OF THE AMERICAN NEGRO

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## INTRODUCTION

The physical anthropology of the Negro in America is a problem which has failed to ensnare the interest of many workers. In this respect it stands in marked contrast to the corresponding problem of the Red Man, about the physical features of whom there has grown up a mass of literature based often upon data of uncertain value and gathered sometimes with instruments or methods of questionable accuracy. The physical anthropology of the American Negro presents an almost untouched field and a very promising one for study.

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In the section of Comparative Anthropology in the Hamann Museum in this University we have gathered up to the present some two hundred and fifty complete skeletons of American Negroes of known age and sex, intending to develop the opportunity for intensive study of this very practical problem. For many of these skeletons there are extensive anthropometric records taken from the cadaver before dissection. Samples of skin and hair from selected areas of most are retained in the laboratory and duplicates deposited in the American Museum of Natural History. Of the later bodies there are in addition photographic records at least of the face and head. It is hoped that other workers will be attracted to this material as it increases and becomes better known.

Despite the original complications entailed in the African ancestry of this material, complications which are duplicated in the White population of this Country, we have in the American Negro a stock upon which we may observe the results of Western civilization, of hybridization, of occupation during a period of definite maximum duration. There is no other human material equally accessible and in which the hybridization involves such markedly distinct original stocks. There are those who would say that the hybridization has been very slight: there are others who feel that we must accept as a potential hybrid, in his ancestry, every American Negro. Be this as it may we have no reliable data at present to guide us. It has appeared to us in this laboratory that the influx of southern Negroes which has taken place during the past few years, in consequence of the large wages in the North, brought us a type of Negro much more "African" in his external features than the type of northern Negro to whom we had previously become accustomed. This observation had led us to investigate the bodies of the Negroes with the object of ascertaining if there be any differential features which can be relied upon, in other words Stock-linked. Skin color and skull form naturally obtrude themselves upon the attention in such an investigation and we are now actively pursuing a research in this laboratory upon the correlation of skin color and skull form. At present it is too early to say what is likely to result from this investigation. Our standardization of skin color has but recently been attained and that of skull form is still in the experimental stage, for in this work nothing is more evident than the almost total inadequacy for correlative work of many stock methods of measuring the skull. The pelvis seemed a profitable source of information and



so far as our observations have progressed this part of the skeleton is much more stable than the skull, as indeed would be anticipated. Nevertheless the skin as the most obvious and accessible part had first to be submitted to standardization. The present paper deals with the results of the research upon skin color.

#### MATERIAL

In this investigation into standardization of skin color the junior author has undertaken the entire labor of estimating color values and all the technical work connected with the checking of these estimates and elimination or reduction of possible errors. Both authors are jointly responsible for the arithmetical calculations involved in the correction of observations on color. The senior author alone is responsible for gathering the data into acceptable form for publication.

For the purposes of this work Miss Van Gorder took samples of the skin of ninety-seven of our American Negro cadavera, hereinafter called Negro-hybrids in order to differentiate the material from true African stock. Representative skins from several White races were also studied as checks. The samples used were taken from the upper part of the upper left arm superficial to the lower portion of the deltoid muscle. This site was chosen because it is a site almost invariably protected by the clothes from the possible effect of direct sunlight and at the same time readily accessible in the living. The sample taken measured about two inches long by one inch broad. After removal it was preserved in 10% formalin in the dark. Some specimens had been several years in preservative before they were used; others were taken from the fresh cadaver and used at once. It was therefore necessary to check observations made under these entirely different conditions and the manner of this check together with many others will appear in the succeeding pages.

The majority of the samples naturally came from adult male cadavera but there are enough from females and children to indicate any relation of age and sex. These matters also will receive attention in their appropriate place.

#### HISTORICAL REVIEW

There have been many observations made and recorded upon the color of the Negro skin which need not concern us here. The only serious attempt at quantitative study was undertaken by Davenport and his pupils<sup>1</sup> and to this work we are greatly indebted for it was upon this that our own was originally based.

<sup>1</sup>Davenport (C. B.)—1913. *Heredity of Skin Color in Negro-White Crosses*. Carnegie Institute of Washington, Publication No. 188. pp. 1-106.

Davenport was concerned chiefly with the heredity of skin color whereas we have as our object simply standardization of the quantitative estimation and the reduction, so far as possible, of errors. It is our desire to use the observations here recorded for correlation with other observations made upon other features of the same individuals. With this distinct difference in ultimate aim it becomes unnecessary to discuss in full detail the whole of Davenport's work especially that relating to heredity. We note that Davenport shows quantitatively the darkening of the skin from birth to about puberty after which curiously enough it appears to become gradually somewhat lighter, and also that there is no sex-linkage in skin color. In his attempt to find pure-bred Negroes with whom to compare observations upon the hybrids, Davenport was compelled to accept individuals who claimed a pure Negro descent. These eighteen individuals are recorded together and show an astonishing difference in the percentage of black (N) in their skins. It is true that they came from three different localities, namely Bermuda, Jamaica and Louisiana and that on the whole the range for each locality was distinct. The darkest skinned were in the main from Bermuda, the lightest from Louisiana and the intermediate from Jamaica. History records that there was very little importation of Negroes direct on to the American continent. The American Negroes came from the West Indies and there was at least the possibility of hybridization before they arrived in America proper. This and hybridization afterwards may account for the lighter color of the Louisiana people. One could not take as serious evidence the statement of any of these individuals that there had been no white blood in their ancestry. But as Davenport points out there is a very marked variation in the skin color of the true African Negro. Nevertheless the ancestors of these individuals must have come from the West Indies and they had got lighter in the process. There are only four of these Louisiana Negroes and therefore it would not be worth while to discuss them except that by doing so we are enabled to indicate several problems raised by Davenport's work and conclusions which proved very valuable to us in the present research. These Louisiana Negroes had thick lips, broad flat nose and typical hair, all features surely which are generally recognized as indicating pure Negro blood. Hitherto we have had no other criteria and have been compelled to adopt these in consequence. It would be interesting to know something about the heredity of such features. Meantime, having no other standard, it is natural that they

should be recorded as evidence in support of the personal statement. In this table on p. 9 one notes that those individuals with a relatively small proportion of black in the skin displayed a somewhat large amount of red pigmentation and further that the combination N+R showed comparatively little deviation from the mean. Davenport interprets this as meaning that the Negro differs in his skin thickness; that those who have thick skins show greater intensity of black pigmentation and those with thin skins have not the red of the blood so greatly obscured. This is an interesting speculation and requires further elucidation.

According to Davenport there are two sharply separated types of Negro according to the percentage of black pigmentation in the skin. One has the mode at 45-49 and the other in the 70's. Further on (p. 13) Davenport makes the following statement as the result of his investigation of the  $F_1$  and  $F_2$  generations.

"There are two (double) factors (A and B) for black pigmentation in the full-blooded negro of the west coast of Africa, and these are separately inheritable."

With these results of Davenport's work in mind and with the Bradley color-top used by him and his pupils as our instrument we set out to investigate the skin color of our Negro-hybrid cadavera.

#### TECHNIQUE OF COLOR DETERMINATION

In order to follow as closely as possible the method used by Davenport so that we might be able to compare properly his results and ours we determined to adopt his technique. We therefore obtained a supply of the Bradley color tops. As the trade name for the top has changed during the period since this work was projected we were no longer able to obtain the tops locally since we were unable to give the correct (sic!) order. It is best therefore to procure the tops direct from the Milton Bradley Company, Springfield, Mass. The toy is now called "The Pupil's Color Top" no. 8109. In the envelope are several large and small color discs. The small ones we discarded but we picked out the black, yellow and white discs of the large series. In addition to these Davenport used a "red." There are two reddish discs in the envelope, the one orange colored and the other a dark shade of red. As it was certainly this which Davenport used we picked it out and combined it as a sector with the other three according to the directions enclosed with the top. We were at once struck by the appearance of the "red" disc which obviously contained a good deal of black and we



decided that some correction must be made in our calculation in consequence.

At the time when Davenport's work was done that very important and useful monograph upon color standards by Ridgway<sup>1</sup> had not been published at least in its final and complete form. Now that this is available it is possible to make the necessary corrections and thus obtain the true proportions of standardized colors in the skin. We compared the black and white discs with the standards in Ridgway and found them identical. The yellow disc we identified with Ridgway's Lemon Yellow, that is pure spectrum yellow. It is a full color with neither white nor black admixture. With the red the case is quite different. The color of the disc is about midway between Carmine (i) and Ox-blood Red (k): that means it is a shade of spectrum red. For practical purposes one may consider it as tone j which has 41% of full color in it mixed with 59% black. Hence every unit of "red" on the red sector of the spinning top represents only 41% of a unit of full spectrum color, the remainder being black and therefore belonging in reality to the black sector. The correction made as a result of this inquiry is quite important and makes for an exactitude of observation not hitherto attainable. It also enables the work to be compared with future investigations along similar lines. To this subject we shall have to return later. At once it may be objected that perhaps we err in using the correction of exactly 59% black. Perhaps we do err by 1% or so but that is negligible since the observations cannot be made within less than a possible error of  $\pm 2\%$ .

Success in the use of the color top was not attained without considerable effort and it is proposed now to state the difficulties encountered.

One of the most formidable, and in the early part of the work, most distressing sources of error was fatigue of the color sense. It soon became apparent, through repeated check observations carried out at daily intervals or longer, that an estimation made promptly when the top was spinning at high speed was invariably more accurate than one on which considerable time had been spent before decision. Pondering over the color rapidly fatigues the color sense. To overcome this the work was done in brief periods at frequent intervals in a quiet room free from interruptions and alone. These ideal circumstances were not invariably possible but they were adhered to as strictly as the circumstances of the laboratory permitted.

<sup>1</sup>Ridgway (R.)—1912. *Color Standards and Color Nomenclature*. Washington.

Light is an important factor in obtaining reliable results. In this work a north light was used, but on dull days in the winter it was replaced by a 150 Watt Nitrogen-filled Mazda electric lamp with large white reflector. This light was carefully tested against north daylight by means of the color tops and proved satisfactory. The results obtained were quite comparable with those secured in daylight.

The background naturally makes a considerable difference to acuity of color sense. The skin was spread upon, and in some cases as stated below, stretched upon a cork board covered with white piece of paper on which also the top was spun, the work being carried out upon a white-tiled bench. Thus the eye encountered no marked change of background color as it would if a black bench had been used.

The angle of observation is a source of error. To ensure consistent results both top and skin were observed from a height of about one foot, the eye being vertically above the two objects.

Speed and evenness in the spinning of the top makes considerable difference to the observation. As the top slows down the color darkens. Consequently color must be estimated without delay while the speed is high. After a little experience this source of error may be discounted.

One of the most troublesome features connected with the work was the necessity of constantly guarding against dirty tops. An amount of grime on the paper sectors which would ordinarily escape detection will show an error of 10% when contrasted with an absolutely new top. A good supply of new tops is the only safeguard against this possible error. The paper discs are not dependable after a few observations have been recorded.

Refraction of light from the surface of the skin may result in erroneous observation. If the moisture be removed from the skin after it has been taken out of the vial of 10% formalin in which it has been preserved, refraction becomes a negligible quantity.

To obviate the personal error in this series all observations were made and recorded by one individual (L. V. G.). Check readings were taken on different days to eliminate psychological errors.

In order to ensure accuracy several readings were always taken and the average of these is used in the final tabulation. The variation in different sets of readings was about 3%. Should a difference of as much as 5% appear subsequent readings were taken and the source of error determined and ruled out.

We found, as did Davenport, that a very slight change in the yellow-white (Y-W) proportion was easily detected, but that, especially on dull days, a much larger change in the black-red (N-R) proportion might escape observation. This is undoubtedly due to the large amount of black (59%) in the red disc. Such an error was occasionally found in checking our results. In such case the obviously erroneous estimate was ruled out.

Some skins have a considerable amount of gray in them and it was impossible to match these exactly. Nevertheless we feel sure that the average readings come well within the 5% range of error which we believe must be allowed especially for comparison of the observations made by different workers. In comparing two spinning tops the difference between the proportions, say N 69 R 25 W 2 Y 4 and N 67 R 26 W 2 Y 5, is easily recognized, but when the two tops are compared with the skin it is difficult to decide which color more nearly matches. This explains the range of error which we have already indicated.

One might very properly ask why we continued to use the top when we had Ridgway's book at hand. Our defense is very simple. Searching through the plates of Ridgway's book for the correct mixture, even after some experience, is a procedure which rapidly dulls the color sense and once one finds oneself in a quandary over a skin it is a sure sign that fatigue has set in. The effort must be abandoned for a time. While we found the book of inestimable value for reference and for standardization we did not find it so practical as the simple color top for the routine observations of this work. Further, after comparison we believe that a color estimation can be made rather more accurately with the color top than with the plates even under the most advantageous conditions for the latter. For example, No. 612 gives a color estimate by the top as: N 57 R 31 W 6.5 Y 5.5. When the correction in the N-R combination is made it stands at N 75.29 R 12.71. We now search through the plates in Ridgway's book for the nearest color and tone. The two authors independently identified the position of this skin on Plate 39, between columns 2 and 3 in the interval between k and m. This on analysis means that the full color of the skin is an orange hue of red represented by the symbol R-O containing 40% red and 60% orange; that with this there is admixture of neutral gray in the proportion of 77% gray to 23% pure color; and that black is present in the proportion of 80% black to 20% pure color. Thus the N value by Ridgway becomes approximately 80% whereas by the top



method it is estimated much more easily and quickly and also more certainly as 75%.

A feature of color estimation which is rather puzzling at first is the curious fact that of two skins the apparently lighter one occasionally contains the larger percentage of black. In explanation on this one turns to Plates 14 and 15 in Ridgway where the appearance of various broken hues with considerable admixture of black gives convincing testimony that the eye unaided is no judge of the percentage of black in any given color mixture.

The error of the red disc is far and away the most important source of confusion in these estimations. It must be corrected invariably or the results are quite apt to mislead. For example we found, as Davenport did, that there are two types of Negro skin one with low N value and a very high R value, the other with a high N value and a very low R value. There was no constant relation between the N and the R values. When the N value diminished the R value rose in far greater proportion. Davenport explained this upon the theory that there are two biotypes of Negro differing in the thickness of the skin. The thicker the skin the more the red capillaries are obscured and the greater the depth of the black pigment. In the first place we were not convinced that the sum of  $N+R$  is "so nearly constant," and in the second we could not hold with the difference in thickness of skin, apart from sexual and age differences, until it should be proved. In the third place we suspected this to be an error of estimation due to the amount of black in the "red" disc. On a former page the information given in Ridgway's book regarding this disc has been cited. In every estimation the value of the black sector must be increased by 59% of the value of the red sector and the value of the red sector diminished accordingly. The effect of this will be noted later in the discussion. At the moment we may state that this correction reduced the range of variation of N to less than half the range in the uncorrected estimates; it makes possible a comparison of skin color with other features, notably of the skeleton; and it explains why when the value of the N sector on the top is small the value of the R sector is disproportionately high. Before we learned to correct our estimates thus we had attempted to make some correlations between skin color and skeleton but obtained only chaotic and quite bewildering results. Applying the corrected estimate we found correlation entirely possible.

Since the actual N value is the sum of the apparent N value plus 59% of the apparent R value one might imagine that various combinations of N and R on the top would give the same result. This is not the case. The correct total is obtained in one position alone of the sectors.

#### TECHNICAL PROBLEMS OF THE WORK

Before passing to the full statement of our results it is necessary to deal briefly with sundry problems which appeared in the course of the investigation.

#### PERMANENCE OF MELANIN

Some of our skins had been removed some years before the actual investigation was carried out. The question arose as to whether these might have bleached out in the meantime. As already stated the skins have always been kept in the dark, each in its separate vial of 10% formalin. Melanin is a very permanent and resistant substance and although we cannot prove the skins to have remained unchanged we have taken every precaution and it is unlikely, on account of the character of melanin, that any appreciable change has taken place. Certainly, as we shall show, no change occurs in the N value of the skin after the first few days of preservation, during the course of our two months' investigation.

#### THE N VALUE IN THE LIVING AND THE CADAVER

The relation of the N value in the living skin to the N value in the cadaver is one to which we have given much thought. Our uncorrected results at first showed a higher N value than did Davenport's uncorrected results. When both were corrected the difference became practically negligible. We have not corrected all Davenport's figures since the greater number of his cases are not directly comparable with ours. They were very distinct hybrids; ours are apparently full Negro in most instances and it is simply our desire to make no unwarrantable assumption which makes us insist upon styling them Negro-hybrids. We have corrected Davenport's estimates on "pure-bred negroes" on his page 18 and it is to these we now refer. The total number is too small to make the statement that the difference between the corrected figures is practically negligible anything more than an impression. But we shall shortly produce evidence to show that skins from fresh cadavera, very red in consequence of seepage into them of much blood, change their N value little or not at all as the blood coloration changes

and the red is lost. Therefore we believe that the *corrected* N value in the skin of the cadaver gives a very close approximation to the true value of N in the living.

EFFECT OF STRETCHING AND WRINKLING SKIN

Some skins, if placed fresh in formalin, become wrinkled. This seems to have nothing to do with the age of the cadaver but it may be related to the length of time after death before the skin is fixed with preservative. Some skins are wrinkled even after being taken, not fresh, but from the embalmed cadaver. To the eye these skins appear darker than the same skins artificially stretched or skins which are normally flaccid. This need not mean a difference in the N value but it suggests it sufficiently strongly to demand investigation. We therefore estimated the color values of the following skins both wrinkled and stretched:

542, 580, 664, 693, 695, 703, 716, 733, 736, 738, 744, 751, 763, 764, 765, 773, 790, 792, 802, 803, 808, 812, 815, 824, 825, 831, 845, 850, 859.

In none of these did we find any change in the N value of more than 2%, which is within the limits of observational error, except in 744.

The average values of skin 744 wrinkled as estimated by the top are: N 79 R 13.5 W 3.5 Y 4. The average values by the top when the skin is stretched are: N 74 R 16.5 W 5 Y 4.5. Corrected, these are respectively: B 86.96 R 5.54 and N 83.73 R 6.67. This is too small a difference to have any significance and were it less equivocal one case alone in the entire number could not influence our judgment. There is no actual change in the N value whether the skin is wrinkled or stretched although to the eye there is an obvious darkening of the skin when it is allowed to become wrinkled. This, I believe, indicates the accuracy possible in N estimation.

If then the change in shade of the skin is not due to increase in the N value it is necessary to discover the true cause. And in discovering this we add one more reason for using the top rather than the color standards in estimating skin color.

Skin 859 shows a striking difference in color between its wrinkled and stretched conditions. This is expressed, uncorrected, as follows:

Wrinkled.....	N 74	R 18	W 3	Y 5
Stretched.....	N 72	R 16	W 3	Y 7



There is no correction necessary for the W-Y combination since Y is a full color. Correcting the N-R combination to the nearest half of one per cent we get:

Wrinkled.....	N 84.5	R 7.5	W 3	Y 5
Stretched.....	N 83.5	R 6.5	W 3	Y 7

We do not regard it as necessary, or in most cases any more exact, to use the decimal but occasionally it has been of some advantage and we therefore sometimes retain the method. The difference of 1% in the N readings is simply an observational error but the difference in R-W-Y combination should not be so regarded for the small change in the sectors which this implies means quite a striking difference on the color top. We do not claim that the figures give exactly the difference between the wrinkled and the stretched skin, but we do insist that this difference corresponds practically to a slight change in the R-Y values rather than to a modification affecting the N value. This obvious difference in color produced by an alteration of the R-Y combination without change of the percentage of black is well shown by Ridgway's plates XIV, XV to which the reader is referred for confirmation of our contention.

When the N value is high we find our results upon the R-W-Y combination more variable because it is relatively more difficult to recognize a small R-W-Y change in these circumstances. In practice we begin to doubt slight variation in the reading when N corrected is 87% or more. This figure corresponds to value of 80% in the uncorrected reading.

It is not to be inferred that there is always a difference in the R-W-Y combination between the wrinkled and stretched skin. If such a difference presents itself we believe that it lies rather in the R-W-Y than in the value of N.

#### SKIN COLOR VALUES IN RELATION TO EMBALMING AND PRESERVATION

In order to eliminate any possible errors induced by the precise method of obtaining the skin we made a number of observations on fresh skin taken from the cadaver before embalming and on the adjoining skin removed after embalming. We also made observations on these same portions of skin at various times after they were taken from the body and had lain in 10% formalin. The investigation follows in full. Only corrected figures are used.

*Cadaver 853 (male, age 36)*

(The first skin estimations which we attempted were done on this cadaver.)

Feb.	8.	Fresh skin wrinkled.....	N 74	R 12	W 6	Y 8
		Fresh skin stretched.....	N 72	R 14	W 6	Y 8
Feb.	9.	Same skin, wrinkled, after formalin one day:				
		Cloudy daylight.....	N 82	R 11	W 2	Y 5
		N-filled Mazda.....	N 80	R 11	W 3	Y 6
Feb.	8.	Cadaver embalmed; skin left in situ till next day.				
Feb.	9.	Skin from embalmed cadaver, stretched naturally, after embalming one day...	N 79	R 13	W 3	Y 5
Feb.	15.	Same skin six days later.....	N 81	R 11	W 3	Y 5
Apr.	12.	Same skin after formalin two months..	N 81	R 9	W 4	Y 6

(A difference of 1% in the W-Y is discounted as an observational error.)

*Cadaver 854 (male, age 19)*

Feb.	9.	Fresh skin wrinkled.....	N 87	R 6	W 4	Y 3
Feb.	9.	Fresh skin stretched.....	N 85	R 8	W 4	Y 3
Feb.	15.	Same skin (formalin).....	N 88	R 7	W 3	Y 2
May	3.	Same skin (formalin).....	N 87	R 6	W 4	Y 3

*Cadaver embalmed Feb. 9; skin taken at once*

Feb.	9.	Embalmed skin, wrinkled.....	N 86	R 9	W 3	Y 2
Feb.	15.	Embalmed skin, wrinkled.....	N 88	R 7	W 2	Y 3
Apr.	12.	Embalmed skin, wrinkled.....	N 87	R 6	W 4	Y 3

*Cadaver 858 (male, age 24)*

Feb.	19.	Fresh skin, wrinkled.....	N 84	R 6	W 7	Y 3
Feb.	23.	Same skin, wrinkled.....	N 85	R 5	W 7	Y 3
Mar.	1.	Same skin, wrinkled.....	N 86	R 5	W 6	Y 3

*Cadaver embalmed Feb. 19; skin taken at once*

Feb.	19.	Embalmed skin wrinkled.....	N 88	R 6	W 4	Y 2
Feb.	23.	Embalmed skin wrinkled.....	N 84	R 5	W 8	Y 3
Mar.	1.	Embalmed skin wrinkled.....	N 84	R 5	W 8	Y 3

*Cadaver 859 (male, age 26)*

This cadaver had an exceedingly red skin. He looked like, but was not, a case of CO poisoning. The redness was due to blood pigment.

Mar.	2.	Fresh skin wrinkled and bloody.....	N 81	R 11	W 4	Y 4
Mar.	8.	Same skin wrinkled.....	N 83	R 8	W 4	Y 5
Mar.	16.	Same skin wrinkled.....	N 83	R 8	W 4	Y 5

*Cadaver embalmed Mar. 3; skin taken at once*

Mar. 3.	Embalmed skin wrinkled and bloody..	N 81	R 11	W 4	Y 5
Mar. 8.	Embalmed skin wrinkled.....	N 85	R 7	W 3	Y 5
Mar. 15.	Embalmed skin wrinkled.....	N 85	R 7	W 3	Y 5
Mar. 15.	Embalmed skin stretched.....	N 83	R 7	W 3	Y 7
Mar. 16.	Embalmed skin stretched.....	N 83	R 7	W 3	Y 7

*Cadaver 860 (male, age 23)*

Mar. 14.	Fresh skin wrinkled.....	N 81	R 12	W 2	Y 5
Mar. 15.	Same skin wrinkled.....	N 81	R 10	W 4	Y 5
Mar. 15.	Same skin stretched.....	N 80	R 11	W 3	Y 6
Mar. 16.	Same skin stretched.....	N 81	R 9	W 3	Y 7

*Cadaver embalmed Mar. 14; skin left in situ for two days*

Mar. 17.	Embalmed skin naturally stretched...	N 80	R 10	W 3	Y 7
Mar. 22.	Embalmed skin naturally stretched...	N 82	R 10	W 2	Y 6

*(Cadaver 862 (male, age 23)*

Mar. 17.	Fresh skin wrinkled.....	N 88	R 7	W 2	Y 3
Mar. 17.	Fresh skin stretched.....	N 85	R 8	W 2	Y 5
Mar. 22.	Same skin stretched.....	N 85	R 8	W 3	Y 4
Apr. 12.	Same skin wrinkled.....	N 87	R 6	W 3	Y 4

*Cadaver embalmed Mar. 17; skin left in situ five days*

Mar. 22.	Embalmed skin stretched.....	N 85	R 8	W 3	Y 4
Mar. 23.	Embalmed skin stretched.....	N 85	R 8	W 2	Y 5
Apr. 12.	Embalmed skin wrinkled.....	N 86	R 7	W 3	Y 4

*Cadaver 866 (male, age about 35)*

Apr. 21.	Fresh skin stretched.....	N 75	R 14	W 4	Y 7
Apr. 22.	Same skin stretched.....	N 72	R 10	W 10	Y 8
Apr. 27.	Same skin stretched.....	N 75	R 10	W 8	Y 7

*Cadaver embalmed Apr. 21; skin taken Apr. 22*

Apr. 22.	Embalmed skin stretched.....	N 74	R 12	W 6	Y 8
Apr. 25.	Embalmed skin stretched.....	N 72	R 10	W 10	Y 8
Apr. 27.	Embalmed skin stretched.....	N 76	R 9	W 8	Y 7

*Cadaver 868 (female, age 60)*

Apr. 22.	Fresh skin stretched.....	N 84	R 9	W 2	Y 5
Apr. 25.	Same skin stretched.....	N 85	R 7	W 2	Y 5
Apr. 27.	Same skin stretched.....	N 89	R 6	W 2	Y 3

*Cadaver embalmed Apr. 22; skin taken Apr. 23*

Apr. 25.	Embalmed skin stretched naturally...	N 86	R 7	W 2	Y 5
Apr. 27.	Embalmed skin stretched naturally...	N 87	R 7	W 3	Y 3
May 2.	Embalmed skin stretched naturally...	N 87	R 7	W 2	Y 4



*Cadaver 873 (male, age 11 m.)*

May	2.	Fresh skin stretched naturally.....	N 60	R 18	W 10	Y 12
May	3.	Same skin stretched naturally.....	N 63	R 12	W 14	Y 11
May	9.	Same skin stretched naturally.....	N 63	R 11	W 14	Y 12

*Cadaver embalmed May 2; skin taken May 3*

May	3.	Embalmed skin stretched.....	N 64	R 11	W 12	Y 13
May	9.	Same skin stretched.....	N 62	R 11	W 15	Y 12

*Cadaver 874 (male, age 23)*

May	2.	Fresh skin stretched.....	N 85	R 9	W 2	Y 4
May	3.	Same skin stretched.....	N 87	R 7	W 2	Y 4
May	9.	Same skin stretched.....	N 87	R 7	W 2	Y 4

*Cadaver embalmed May 2; skin taken May 3*

May	3.	Embalmed skin stretched.....	N 84	R 9	W 2	Y 5
May	9.	Same skin stretched.....	N 85	R 7	W 3	Y 5

In the foregoing, as in all our cases, it is to be understood that the skin samples, both those freshly taken and those removed after embalming, were kept in the dark in 10% formalin.

Examining the above figures closely, first with special reference to the N value we note that the variation in estimation of N under all conditions is not more than 4% except in nos. 853 and 868. In 868 the variation is 5% but it seems plain from the other figures on this skin that the estimate made on the fresh skin on Apr. 22 was somewhat inaccurate. In 853 the extreme variation was 10%. This was the first skin examined and the estimates made on the fresh skin, on the first day of this investigation, namely Feb. 8, naturally could not be worked over and checked up on later occasions. One would be safe in eliminating these figures as palpable errors; and if this be done the extreme variation in this case is only 3%. The important conclusion to be derived from this part of the work is that the N value is unaffected by embalming methods, by preservation in formalin (at least for three months and probably therefore for much longer especially if the skin be kept in the dark), by wrinkling or by stretching. Even a very bloody skin with a high R value, no. 859 for example, does not appreciably alter its N value even though to the naked eye it appears to grow darker as the blood pigment becomes changed into methaemoglobin. This is a very valuable result for it enables us to go ahead with the investigation of skins taken from cadavera with a fair hope that our estimates are of practical accuracy.

Examination of the R value shows that in bloody skins there may be a fairly high percentage of red and that this drops as the methaemo-

globin forms. No. 859 and 866 are typical examples. There may be a slight increase in the W-Y value as the red diminishes. It seems possible that we have here an indication of the difference between the skin in the living and in the cadaver. It would be valuable to obtain color estimates before and after death but this is exceedingly difficult to carry out. We did propose to attempt it but gave up the project since patients who are exhausted and already near to death would not give an incontestable R value owing to their condition, and upon other patients the probability of getting the cadaver skin would be a gamble.

The change in the R value it will be noted, is a very variable quantity and no exact estimate of it can be made, although a "red" skin will undoubtedly change more than one in which the blood pigment is not so obvious. It is not the R value with which we are concerned and it is unlikely that the R value is important since we have definitely separated the N value from it. Hence we may leave the question of the R value, in its relation to death, unsettled but from our general experience we should imagine that a change of 5% or even more would be not unlikely. The important thing is that the N value remains the same.

#### EFFECT OF JAUNDICE IN THE SKIN

Occasionally we discovered a skin sample in which the normal brownish-black shade was bronzed as the result of jaundice. We therefore decided to investigate the relation of bile pigment to permanence of skin color and reliability of color estimate. During the research we received two cadavera suitable for this work and the following (corrected) results were obtained upon these.

##### *Cadaver 855 (male, age 28)*

Feb. 9.	Fresh skin stretched.....	N 70	R 19	W 8	Y 3
Feb. 15.	Same skin stretched.....	N 80	R 11	W 3	Y 6

##### *Skin transferred to alcohol Feb. 15*

Apr. 11.	Same skin stretched.....	N 83	R 3	W 7	Y 7
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##### *Cadaver embalmed Feb. 9; skin taken at once*

Feb. 9.	Embalmed skin stretched.....	N 81	R 11	W 3	Y 5
Feb. 15.	Same skin stretched.....	N 84	R 6	W 4	Y 6
Apr. 11.	Same skin stretched.....	N 83	R 3	W 8	Y 6

##### *Cadaver 857 (male, age 24)*

Feb. 19.	Fresh skin stretched naturally.....	N 78	R 12	W 4	Y 6
Feb. 23.	Same skin stretched.....	N 82	R 8	W 5	Y 5
Mar. 1.	Same skin stretched.....	N 85	R 6	W 4	Y 5

*Skin transferred to alcohol Mar. 1*

May 11. Same skin stretched, naturally.....	N 84	R 6	W 5	Y 5
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*Cadaver embalmed Feb. 19; skin taken at once*

Feb. 19. Embalmed skin stretched naturally.....	N 78	R 12	W 4	Y 6
Feb. 23. Same skin stretched naturally.....	N 84	R 6	W 4	Y 6
Mar. 1. Same skin stretched naturally.....	N 83	R 6	W 4	Y 7
May 11. Same skin stretched naturally.....	N 85	R 6	W 3	Y 6

After the fairly reliable results obtained in the previous cases examined one is inclined to discard these. The olive shade in the skin renders any estimate merely an approximation of rather doubtful value. From the study of these cases and others we found it advisable to throw out estimations upon any jaundiced skin as probably inaccurate or at least uncertain. They are the only instances where there was an indubitable change in the N value so far as the estimations went.

It will be seen that by immersing one sample of each skin in alcohol for two months we endeavored to discover if the solvent action of alcohol has any effect upon the bile in the skin. The results are negative so far as the large range of error in these skins permits one to judge.

## THE N VALUE IN WHITE STOCK

Davenport states (1, p. 8) that "the untanned skin-color formula of the Caucasian contains from 0 per cent to 7 per cent black and probably, in brunets, as much as 10 per cent black." He gives as the values of his own wrist tanned during the summer N 8 R 50 W 9 Y 33. We took the skins of two brunet Italian of the same family and obtained the following (uncorrected) results:

Cad. 625, male, Italian, age 6.....	N 59	R 29	W 5	Y 7
Cad. 637, female, Italian, age 11.....	N 51	R 32	W 7	Y 10

We also examined the skin of three Mexicans thus:

Cad. 790, male, Mexican, age 34.....	N 60	R 27	W 5	Y 8
Cad. 813, male, Mexican, age 22.....	N 50	R 24	W 15	Y 11
Cad. 827, male, Mexican, age 30.....	N 50	R 25	W 15	Y 10

Even supposing the Mexicans had Indian blood we observe that a brunet of White stock (Italian) may have an N value of much more than 10%, but these figures are uncorrected. Making the proper correction the following are the color values:



Davenport's wrist.....	N 37	R 21	W 33	Y 9
Cadaver 625.....	N 76	R 12	W 5	Y 7
Cadaver 637.....	N 70	R 13	W 7	Y 10
Cadaver 790.....	N 76	R 11	W 5	Y 8
Cadaver 813.....	N 64	R 10	W 15	Y 11
Cadaver 827.....	N 65	R 10	W 15	Y 10

We note from the above findings that the Negro has no monopoly of the large N value. It is true that in White stock one would never expect to find such high values for N as in the Negro. Nevertheless the Mediterranean race at least possesses as N value falling well within the range of the Negro. This fact is of considerable value when we come to make correlations between the N value in the skin with other bodily features. Hybrids as we see them here between Negroes and the Mediterranean race, especially eastern Mediterranean peoples, provide very difficult problems. Skin color values alone will not give any decisive information upon some of the hybrid or suspected hybrid problems in our material. It is for this reason in part that such complete data of hair, physical measurements and photographs are kept.

#### GENERAL RESULTS OF THE STUDY

In the foregoing pages we have observed that melanin is a very resistant and permanent substance and that it can be estimated with considerable accuracy even in the presence of other color components in the skin. We have seen that the N value probably does not change appreciably with death, that it is uninfluenced by embalming or by preservatives, and that the condition of the skin (wrinkled or stretched) has no influence upon its estimation. The N value may be as great in White stock as it is in many Negroes. It is estimated with greater difficulty in grayish skins; and in jaundiced skins the estimate is untrustworthy. We may now scan the collected results of the entire investigation. These will be given in corrected form only. In uncorrected condition they are quite misleading for reasons already dwelt upon.

#### SKIN COLOR ESTIMATION ON NEGRO-HYBRIDS

Cadaver	Sex	Age	N.	R.	W.	Y.	Cadaver	Sex	Age	N.	R.	W.	Y.
526....	F	11	84	8	3	5	548....	M	25?—	86	6	4	4
530....	F	45	71	16	7	6	553....	M	45	80	10	6	4
538....	M	38	89	5	3	3	558....	M	41	88	5	3	4
540....	M	ca 45	85	7	4	4	561....	F	25	83	10	3	4
542....	M	20?+	87	5	5	3	563....	M	29	80	9	5	6
543....	M	35-40	77	12	4	7	568....	M	40?—	89	6	2	3

Cadaver	Sex	Age	N.	R.	W.	Y.	Cadaver	Sex	Age	N.	R.	W.	Y.
569....	M	29	87	6	3	4	778....	M	28	76	10	4	10
574....	M	46	74	13	5	8	779....	M	38	88	5	3	4
580....	M	40	83	8	4	5	780....	M	60	64	12	14	10
598....	M	30	88	5	3	4	782....	M	23	84	8	3	5
612....	F	36	75	13	6	6	791....	M	28	83	7	4	6
624....	F	6	88	6	3	3	792....	M	23	86	6	3	5
632....	F	10	85	9	3	3	795....	M	54	75	12	5	8
633....	F	13	88	5	3	4	802....	M	27	86	5	5	4
642....	F	27	75	10	7	8	803....	M	41	86	6	3	5
657....	F	40	79	9	7	5	807....	M	20	91	4	2	3
662....	M	35?—	87	5	4	4	808....	M	20	87	5	4	4
664....	M	35	87	5	5	3	809....	M	26	89	6	2	3
668....	F	37	77	10	4	9	811....	M	40	84	7	4	5
685....	F	35-40	77	9	8	5	812....	M	37	84	8	3	5
693....	M	18	91	4	3	2	814....	M	35	75	9	7	9
695....	M	18	91	4	3	2	815....	M	ca 33	87	5	4	4
698....	M	22-24	86	7	3	4	822....	M	35	77	9	6	8
703....	M	22	84	4	8	4	824....	F	ca 30	88	5	3	4
704....	F	29	90	5	2	3	825....	M	21	85	6	4	5
705....	M	33	79	8	7	6	831....	M	47	85	7	3	5
709....	M	33	88	5	4	3	835....	M	41	87	6	3	4
710....	M	10	82	9	5	4	839....	F	60	71	11	5	13
716....	M	27	88	5	4	3	840....	M	35	70	8	12	10
718....	M	39	84	6	7	3	842....	M	53	77	9	8	6
721....	M	18	88	6	3	3	845....	M	21	87	7	3	3
725....	M	44	75	10	7	8	846....	M	22	82	9	3	6
729....	M	45	79	8	6	7	849....	M	6 mo.	72	11	10	7
733....	M	40	89	5	4	2	850....	M	23	85	7	5	3
735....	M	ca 40	86	6	5	3	851....	M	48	88	5	4	3
736....	M	40	80	9	7	4	853....	M	36	81	11	3	5
738....	M	ca 35	84	10	2	4	854....	M	19	87	7	3	3
744....	M	22	86	7	3	4	858....	M	24	85	5	6	4
751....	F	65	89	5	3	3	859....	M	26	83	8	4	5
761....	M	35	88	5	4	3	860....	M	23	81	10	3	6
763....	M	35	76	8	8	8	862....	M	23	87	7	2	4
764....	M	25	88	6	2	4	864....	M	48	82	7	5	6
765....	M	22	82	8	5	5	866....	M	ca 35	74	12	7	7
766....	M	40-45	90	5	2	3	868....	F	60	87	7	2	4
773....	F	60	69	11	11	9	872....	F	8	78	11	3	8
775....	M	37	86	7	3	4	873....	M	11 mo.	62	13	13	12
777....	M	30-35	83	9	3	5	874....	M	23	86	8	2	4

In addition to the foregoing are three jaundiced skins for which the accuracy of estimate is questioned. These are:

Cadaver 847.....	M	age 50	N 83	R 6	W 2	Y 9
Cadaver 855.....	M	age 28	N 81	R 8	W 5	Y 6
Cadaver 857.....	M	age 24	N 82	R 8	W 4	Y 6

## RESULTS OF THE QUANTITATIVE DETERMINATION OF N

Eliminating the three jaundiced skins which indeed do not appear in any of our assembled results there are 94 Negro-hybrid skins in the foregoing table. We must now assemble the determinations in class frequencies of N, of R, and of N+R.

Class N%	Frequency	Class R%	Frequency	Class N+R%	Frequency
60-64	2	0-4	4	75-79	3
65-69	1	5-9	69	80-84	6
70-74	6	10-14	20	85-89	20
75-79	16	15-19	1	90-94	57
80-84	21			95-99	8
85-89	43				
90-94	5				
Total	94	Total	94	Total	94

In each of these tables there is only a single mode. For the N value the mode is 85-89%, for the R value 5-9% and for the combined N+R values 90-94%. Before correction of our estimates we found the tendency to two modes as determined by Davenport and interpreted by him as evidence of dimorphism in the skin color. We therefore desire to emphasize the disappearance of this evidence when the necessary correction for the red has been made.

In order to compare the above tables with Davenport's work the proper corrections for his determinations must be made. The corrected N values for the "pure-bred" Negroes of Bermuda (p. 9) are, in order of Davenport's table, the following: 83, 82, 83, 86, 65, 86, 69; for table 2, Jamaica, they are: 75, 77, 69, 71, 69, 75, 65; for table 3, Louisiana, they are: 61, 64, 59, 87. Arranging these corrected estimates in order of class we obtain the following:

55-59%—1	60-64%—2	65-69%—5	70-74%—1
75-79%—3	80-84%—3	85-89%—3	

From this we note that the evidence in favor of two modes has diminished and in view of the small number of estimations the evidence of the corrected figures is quite equivocal. As a result of our observations therefore we do not feel able to agree with Davenport regarding evidence of possible dimorphism of the black element in skin color in quantitative determinations of the N value in our cadavera and in his Negroes as recorded on p. 9. There we shall let the matter rest



for the present since our work does not take us into the subject of heredity.

We must now glance at the relation of the N value to age. Davenport and other previous workers on this subject have called attention to the rather rapid increase of black pigment in the skin of Negroes up to and including puberty and the diminishing value of N in the later part of life. Indeed from puberty onwards the N value is believed to grow gradually smaller and to take on a more rapid diminution after middle age. Assembling our observations according to age we obtain the following table.

Age class	Number of skins	Average %N.
0-9	4	75
10-19	8	87
20-29	30	85
30-39	26	82
40-49	19	83
50-59	2	76
60-69	5	76
—	—	—
Total	94	—
—	—	—

The total number of skins in the several age periods varies very considerably and affects the strict accuracy of results. Further the total number of observations is still too small for a final decision. Nevertheless our results so far as they go plainly confirm the work of previous investigators. The period of darkest skin is 10-19 years, but the average of this period is fairly steadily maintained until the late forties after which there does seem to be a diminution in the blackness of the skin.

The question naturally arises as to whether the mode shown by our quantitative determinations as occurring at 85-89% for the N value may not have some relation to the age of the specimen from which the samples were drawn. It is at least suggestive that the great mass of the observations should be drawn from individuals between the ages of twenty and fifty and so few from outside this range. It is also suggestive that 43 specimens should give an N value between 85% and 89%, while at the same time 38 skins should come from the life period between ten and thirty years, a period namely during which the average N value is between 85% and 89%. This question cannot be satisfactorily

answered without further investigation and the determination of N value of many more skins outside the range of twenty to fifty years. Against the implied supposition of the foregoing sentences there is the fact that the average N value of our eight skins between ten and twenty years is 87%, the highest average N value obtained.

#### SUMMARY

The investigation of which the results are recorded in this paper was undertaken as part of a larger research upon the correlation of various physical features, notably skin color, hair form and skeletal characteristics. It is therefore not complete in itself and represents primarily our effort to secure accuracy in the quantitative estimation of skin color. The results briefly stated follow.

1. If the Bradley color top is to be used in the estimation it is essential to make necessary correction for the occurrence of a considerable amount of black in the red disc.
2. Melanin gives a fairly permanent coloration to the skin.
3. There is probably very little change in the N value of the skin between the living and the dead.
4. The N value is not affected by stretching or wrinkling the skin.
5. The N value is unaffected by embalming methods or the use of preservatives.
6. Jaundice renders estimation of the N value very unreliable.
7. The N value cannot be called upon as a race distinction: brunets of White Stock have as high an N value as many Negroes.
8. The corrected figures upon the N value show only one mode and not two as do the uncorrected figures.
9. The statements of previous workers regarding the increase of black pigmentation in the skin up to puberty and the decrease in the later part of life are confirmed by our observations so far as they go.

## PRESERVATION OF SKELETONS

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During the excavations conducted by Phillips Andover Academy at the ruins of the Pecos Pueblo, about thirty miles southeast of Santa Fe, New Mexico, some six hundred skeletons were uncovered and preserved. A development of a method for handling skeletons in the field resulted. Altho the method here described is only applicable under similar natural conditions, it is offered for record as an example of the manner in which one archaeological expedition handled a large number of skeletons.

The Pecos Indians used the rubbish heaps of the village (most of which are on the eastern side of the low mesa) as their cemeteries. The natural deposit surrounding the pueblo is a hard red clay, a much more difficult substance to dig in than the comparatively loose earth of the rubbish heaps. The few grave shafts which were identified showed that the burials were usually made in pits just large enough to receive the bundled body, and only one and a half to two feet deep. Since, however, the rubbish heaps were continually increased by small daily increments, those skeletons buried in shallow graves during the early periods of the occupation of the site, became more and more deeply covered until some of them were under as much as twenty-two feet of earth. A column of earth of twenty feet or so exerts an enormous pressure, which was clearly recorded by the crushed condition of the bones and burial furniture in some of the early burials. The bones were, however, usually dry, and well-preserved from all other destroying agencies, requiring, therefore, practically no application of paraffin or other preservative upon excavation.<sup>1</sup>

The relatively small surface of the rubbish heaps in proportion to the population and length of occupancy of the site (nearly the entire

<sup>1</sup> For treatment of bones in bad condition see Hrdlička, A., Directions for collecting information and specimens for physical anthropology. *Bull. U. S. Nat. Mus.*, Part R, No. 39, Wash., 1904, pp. 12-13.



range of pueblo history in the Rio Grande valley), resulted in a superabundance of skeletal material in most of the trenches run through the heaps. An examination of the maps of the work showed that, horizontally speaking, skeletons were found most frequently in certain ill-defined zones. The burials were distributed vertically as well as horizontally. The congestion at times was so great that both horizontal maps and vertical sections on large scales were required in order to record the locations of the individual burials. Several times as many as twenty skeletons were exposed in the course of one day's work in one of the deeper rubbish trenches. The greatest congestion occurred in a column of rubbish twenty-five feet long, five feet wide, and twelve feet deep, in which thirty-four burials were found. This means an average of one in every forty-four cubic feet, i. e., a column of earth approximately four feet long, two feet wide, and six feet deep. The fact that these burials were made at different periods, and with practically no disturbance of those which antedated them emphasized the evidence regarding shallow graves.

#### EXCAVATION AND REMOVAL

Skeletons were found under nearly every possible condition. Usually the men working on the face of a trench exposed some one bone or group of bones, such as toes, fingers, one end of a humerus or femur, or the skull. Occasionally an unavoidable accident was caused by the entry of a pick into a cranium, the presence of which was entirely unsuspected.

Digging stopped at once in the immediate vicinity of the exposure. An examination of the visible bones was made in order that the position of the skeleton might be determined before any work was done. Experience familiarizes one with possible positions so that as a rule it is an easy matter to determine where the bones probably lie. The normal position in this locality was fully flexed, on the face, or on either side, but semi-flexed postures did occur. During the late period a few burials were at full length, either on the face or on the back, with the feet crossed. Occasionally unusual positions caused much confusion.

After the probable position of the skeleton was determined the cleaning for study and record began. It was found that some of the better workmen could be trained in a short time to clean skeletons in an entirely satisfactory manner. The primary purpose of this cleaning was to expose to view just enough of the bones to make clear their position. If a photograph was to be taken the cleaning was more thorough. The

location of the burial with respect to the excavations controlled to some extent the preliminary work.

The first step in cleaning was to remove all earth more than four or five inches above the skeleton with a hand pick and shovel. Occasionally a skeleton was exposed near the base of the face of a deep trench. It had to be re-covered until the trench work reached such a point that the bones could be easily cleaned. In some cases a small cave was dug in the side of the trench in such a manner that the burial lay on the floor of it.

When the mass of earth over the skeleton was removed the more delicate work of actually cleaning the bones was done with a jack-knife and fine brush. Two general rules insured good work. First nothing but earth was moved. The bones and accompanying furniture were brushed only. Secondly no object in the burial was undermined. Special cases occasionally demanded a departure from these principles. If it proved necessary to remove some of the accompanying objects, notes and drawings were taken during the process of removal. Occasionally the position of the bones required the undermining of some of the long bones in order that the position of the skeleton could be determined. This undermining was, however, as slight as possible and plenty of adequate support was left for the bones so treated.

After the position of the skeleton was clear notes were taken as soon as possible. In case many skeletons were being exposed, one individual did nothing but take notes on them until all were cared for. Best results were obtained by the use of a printed form, which made all the skeletal notes uniform and shortened the time of recording as well. The expedition used a form printed on a five by eight inch card (see figure). All skeletons were numbered serially in the order of their discovery, without regard to location, either vertically or horizontally. The sex and age were roughly determined, subject to more careful study in the laboratory. The condition of the bones in general was then noted, with a remark, if necessary, about any condition of special interest. The furniture found in the grave was listed, with notes in regard to its condition, position with respect to the bones, and its field catalogue number. The last was often not obtainable until later in the day, but it was a valuable check on the catalogue number of the specimen later. Under "remarks" any notes regarding the relation of the burial to its immediate surroundings were entered. The grave was then located with reference to the fifty foot square in which it

occurred. When a more accurate location was necessary, this was easily recorded in the same manner after measuring the coördinates of the position from the nearest survey stake. The depth from the surface and the height above the floor of the rubbish heap was important, since it located the grave stratigraphically. Sometimes conditions were such that the height above bottom could not be determined, in which case the depth was of still greater importance. The recording of the date found, and the initials of the cleaner and recorder completed the notes. Then a diagram of the position of the bones was made. The reverse of the card was blank, to be used for further notes.

If the skeleton was of special importance either because of its position or the material found with it, it was then photographed. When only a few skeletons occur at a given site, it is best to photograph all of them, but where hundreds are found, the conditions of burial are so often nearly identical that the accumulation of such quantities of photographs would be more of a hindrance than help. For a photograph the bones and furniture were brushed sufficiently to make them stand out against the dark background of the earth. It proved to be essential that the skeleton number be placed in the photograph in some manner, for identification later. A card with a pencilled number was entirely inadequate because it was either too small or the light struck it in such a manner that the number was not photographed. The best method is the use of a series of tin house numbers which can be stuck in the earth near the bones.

After the recording and photographing, the burial was removed. This was also done by trained workmen. Force was never used in removing any of the bones. Everything over a given bone was taken care of before it was moved. After the burial was apparently entirely removed, the earth about the skeleton was loosened and sifted through the fingers, searching for small potsherds, beads, toe and finger bones, and small skull fragments. Before actual removal was begun temporary receptacles in the form of heavy manila paper bags bearing marks of identification were placed at hand ready for use. The bones were put in one or two of these bags, and all the burial furniture, including potsherds and noteworthy stone and bone, in one or two more. The bags containing the bones bore the number of the skeleton and the number of bags used for it. This last number was invaluable at the time of assemblage for packing. A fraction was used, in which the numerator was the skeleton number, and the denominator the number



of bags in which the bones were put. This identification mark, in the upper right hand corner of one wide side, was large and clear, made with a soft pencil, so that it could be easily seen. On the bags containing the furniture a similar mark was used with the addition of the abbreviation "skel."

#### PACKING AND SHIPPING<sup>2</sup>

The skeletons in their temporary receptacles were stored each day on shelves in the building at the ruins. At irregular intervals during the field season the skeletons collected were packed. Congestion in the field storage rooms and unnecessary handling of bags were, of course, avoided as far as possible.

Bones are best packed in light material, but efficiency should not be sacrificed for weight. The containers may be either of wood or fibre. If a wooden box is used, it may serve later as a permanent storage case for the material in the museum. On the other hand fibre boxes or cartons are lighter and more easily transported when empty because of their collapsibility. Compo-board or beaver board cartons are more serviceable, because of greater strength, than those of corrugated cardboard. A container may be used with sides of wood, top and bottom of beaver board, and partitions of cardboard. The containers used at Pecos were of the corrugated carton type. It was found that these boxes did not keep their shape and were apt to be very weak if once wet, even when waterproofed. Handling in shipping seriously wrecked one or two of them.

The shipment boxes used held two complete adult skeletons. The dimensions given below proved entirely satisfactory for Indian skeletons, and have the added advantage of being more easily obtained from manufacturers than odd sizes. Each box was 24×18×9 inches, opening on its largest side. For two adult skeletons two partitions, one lengthwise and one crosswise, were used for each box, since each skull was in a compartment by itself. There was such a large percentage of fragmentary and immature skeletons that often many more than two were put in one box, necessitating one and a half to twice as many partitions of each size as there were boxes. In the shipment sent east as many as fifteen skeletons, all infants, were put in one box, in which four cross partitions and two lengthwise partitions were used. There is a great advantage in using partitions of cardboard, because of their adaptability to the needs of each specimen. An examination of the material

<sup>2</sup> See Hrdlička, A., *o. c.*, 13-14.

to be packed in one box gave the relative proportions needed in the different compartments. The necessary partitions were then cut so that they fitted together like the partitions of an egg-box.

The material in which the bones are packed within the box depends largely upon what is obtainable. The only requirement is that the bones do not rattle. The weight and lack of cohesion of sawdust practically prohibits its use. Paper has not sufficient elasticity. Shavings or shredded cedar bark should be satisfactory, but excelsior is probably the best packing material. Dried grasses or plants may be used where an expedition is unable to obtain manufactured material. At Pecos hay was used with some straw, the former being by far the more satisfactory. If the boxes are handled a great deal, the bones are apt to shake down through the hay.

The actual packing can be done most expeditiously and with least confusion if a definite system be adopted and followed. Four men working together gave the best results. Two men, seated one on each side of the box, did the actual packing. In front of each man was a clear space, either on the floor or a table, where the contents of the bag or bags which were to be packed, were put. At one end of the box was a pile of the packing material from which the packers drew their supply. The bones were packed in the box in layers, alternated with layers of the packing material. The skull was placed in the small compartment at one end of the box, surrounded by hay, after the necessary wrapping and binding of teeth and loose parts had been completed. When the skeleton was all packed the remaining earth was carefully examined for teeth and small bones, and then cleared away, leaving a clean area for the next specimen. This eliminated any opportunity for confusion of bones of different skeletons, and each packer handled only one specimen at a time. A third man assembled and prepared the skeletons for each box, and assisted in the sealing. The fourth man prepared the box and partitions for the packers and sealed the filled boxes. Since the boxes were collapsible both the top and bottom were sealed with gummed paper strips, at least three inches wide.

Great care was taken to insure proper means of identification of the packed material. A clearly marked slip was placed within each compartment of the box, and on one side of the box the numbers were written large with a crayon. A rough diagram of the compartments within was drawn on the top of the box, showing the number associated with each.

The final step in packing was the crating of the boxes. A strong and compact crate was built of one-inch boards, four inches wide, which held sixteen boxes, making a total weight of about 350 pounds when shipped. These crates withstood the journey from New Mexico to Cambridge, but were badly smashed by the express man delivering them. A crate weighing not more than 200 pounds is better. Eight boxes to a crate gives the best results.

If cardboard boxes are used special precautions should be taken to protect the crates from the weather. The crate, in this case, should also be so constructed as to give the least possible opportunity for denting and tearing the cardboard by contact with other shipments.

Shipping facilities vary greatly with the location of the work. The ordinary freight rate for human bones buried more than forty years was three times first class in 1918, while the express rate was only first class. It proved to be a saving to send the entire shipment of two and a half tons by express to Cambridge, for by freight it cost more to Chicago alone. The six hundred odd skeletons filled, when crated, a surprisingly large amount of space, about half a freight car. Arrangements in regard to rates and space should be made in advance, securing a special rate and an extra car if possible.

In conclusion, then, the handling of skeletal material in the field<sup>3</sup> is divided into two large divisions, the excavation and removal, and the packing and shipping. Each stage of the work raises detailed problems which must be solved by each expedition with due regard to the conditions under which the work is carried on.

No.—658

SEX—♀

AGE—Adult

CONDITION—Medium, skull crushed

POSITION—Flexed, on face, head south

LOCATION—1000/E 150

DEPTH FROM SURFACE—39"

HEIGHT ABOVE BOTTOM—43"

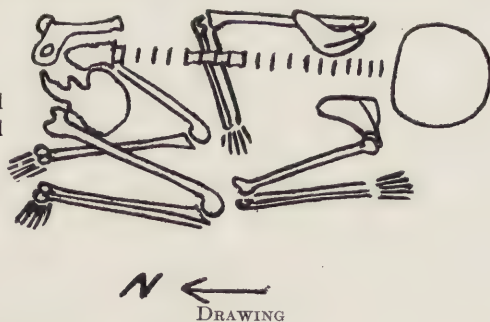
FOUND—7/12/16

CLEANED BY—M. V.

NOTED BY—C. E. G.

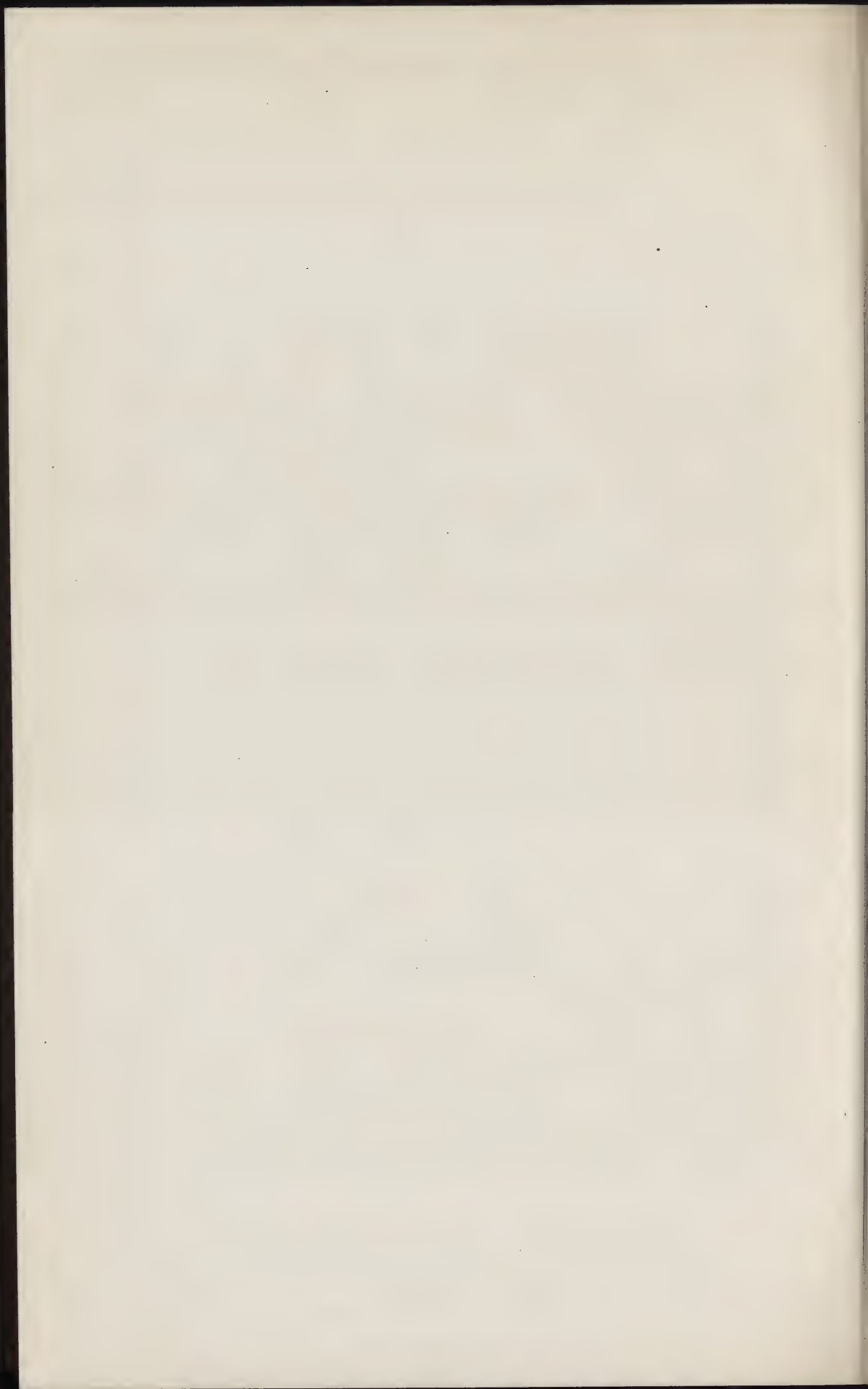
FURNITURE—Glaze 4 bowl inverted (#2127) close over hips

REMARKS—1 ft. below #653; white ash layer 6" below pelvis.



<sup>3</sup>For the care of skeletons in the museum and laboratory see: Hrdlička, A, Arrangement and preservation of large collections of human bones for purposes of investigation. *Am. Naturalist*, 1900, XXXIV, 9-15; and Oetteking, B., Suggestions for cataloguing of anthropological material. *Am. Anthropol.*, 1916, XVIII, 398-410.





## SPECIAL COMMUNICATIONS

### HEIGHTS AND WEIGHTS OF AMERICAN CHILDREN

Dr. A. Hrdlička:

Acting on your suggestion, I am enclosing herewith a copy of the basic tables of heights and weights for white children under six years of age, obtained during the last three years by the Children's Bureau.

These tables show average heights and weights by age from birth to 72 months and average weights for children of different heights. They are based upon measurements of 167,024 white children.

The records included in the tabulation were carefully selected from over 2,000,000 records received by the Bureau during the Children's Year Campaign. The basis of selection was fourfold: (1) the record card must have been signed by a physician; (2) no serious defects should have been noted; (3) the child must have been weighed and measured without clothing, as verified by the physician signing the card; (4) all essential items must have been answered.

The children included in the tabulation were three-fourths of native parentage, one-twentieth of British and Irish parentage, and the remainder of Scandinavian, Italian and other racial stocks. They represent children from every part of the country. The averages for white children of native parentage agree very closely with these averages for all white children.

The eventual full report will contain comparisons of rural and city children, of children of native parentage, children of Italian, German and Scandinavian parentage, and a study of the correlation between the presence of certain abnormal conditions and stature and weight.

Sincerely yours,

ROBERT M. WOODBURY,  
Director, Statistical Research, Children's Bureau.

March 15, 1921.

TABLE I A

AVERAGE STATURES AND WEIGHTS, BY SEX, FROM ONE TO SEVENTY-ONE MONTHS; SMOOTHED FIGURES, EXACT AGES; WHITE CHILDREN

Exact age (months) (i. e. just 1, 2, 3, or so many months)	White boys		White girls	
	Stature (centimeters)	Weight (kilograms)	Stature (centimeters)	Weight (kilograms)
1.....	55.5	4.53	54.4	4.27
2.....	58.5	5.35	57.3	4.98
3.....	61.2	6.06	59.8	5.62
4.....	63.4	6.69	62.1	6.20

TABLE I A  
AVERAGE STATURES AND WEIGHTS, BY SEX, FROM ONE TO SEVENTY-ONE  
MONTHS; SMOOTHED FIGURES, EXACT AGES; WHITE CHILDREN—*Cont'd*

Exact age (months) (i. e. just 1, 2, 3, or so many months)	White boys		White girls	
	Stature (centimeters)	Weight (kilograms)	Stature (centimeters)	Weight (kilograms)
5.....	65.4	7.24	64.0	6.71
6.....	67.1	7.71	65.7	7.17
7.....	68.6	8.12	67.1	7.57
8.....	69.9	8.48	68.5	7.92
9.....	71.1	8.79	69.7	8.23
10.....	72.2	9.06	70.8	8.50
11.....	73.3	9.32	71.9	8.75
12.....	74.3	9.56	72.9	8.98
13.....	75.4	9.78	73.9	9.20
14.....	76.4	10.01	74.9	9.40
15.....	77.3	10.23	75.9	9.61
16.....	78.3	10.44	76.9	9.82
17.....	79.2	10.65	77.9	10.03
18.....	80.2	10.86	78.9	10.24
19.....	81.1	11.07	79.8	10.45
20.....	82.0	11.26	80.7	10.65
21.....	82.8	11.45	81.5	12.65
22.....	83.6	11.63	82.3	11.00
23.....	84.3	11.81	83.0	11.17
24.....	85.0	11.97	83.7	11.34
25.....	85.8	12.14	84.4	11.50
26.....	86.4	12.31	85.1	11.67
27.....	87.1	12.47	85.9	11.84
28.....	87.8	12.64	86.6	12.02
29.....	88.5	12.82	87.4	12.20
30.....	89.2	12.99	88.1	12.38
31.....	89.9	13.16	88.8	12.55
32.....	90.6	13.33	89.5	12.71
33.....	91.2	13.48	90.1	12.87
34.....	91.8	13.62	90.7	13.02
35.....	92.3	13.76	91.2	13.17
36.....	92.9	13.88	91.8	13.32
37.....	93.4	14.01	92.4	13.46
38.....	94.0	14.15	93.0	13.59
39.....	94.5	14.29	93.6	13.74
40.....	95.1	14.44	94.2	13.89
41.....	95.7	14.60	94.8	14.04
42.....	96.3	14.76	95.5	14.19
43.....	97.0	14.91	96.0	14.33
44.....	97.5	15.06	96.6	14.45
45.....	98.1	15.20	97.1	14.58
46.....	98.6	15.32	97.6	14.70
47.....	99.1	15.44	98.1	14.81
48.....	99.5	15.54	98.6	14.93
49.....	99.9	15.64	99.0	15.05
50.....	100.3	15.78	99.5	15.17
51.....	100.8	15.85	100.0	15.29
52.....	101.2	15.96	100.5	14.97



TABLE I A

AVERAGE STATURES AND WEIGHTS, BY SEX, FROM ONE TO SEVENTY-ONE MONTHS; SMOOTHED FIGURES, EXACT AGES; WHITE CHILDREN—*Cont'd*

Exact age (months) (i. e. just 1, 2, 3, or so many months)	White boys		White girls	
	Stature (centimeters)	Weight (kilograms)	Stature (centimeters)	Weight (kilograms)
53.....	101.8	16.09	101.1	15.57
54.....	102.3	16.23	101.7	15.71
55.....	102.9	16.37	102.2	15.87
56.....	103.5	16.53	102.8	16.01
57.....	104.0	16.68	103.3	16.15
58.....	104.5	16.83	103.8	16.28
59.....	104.9	16.98	104.3	16.42
60.....	105.4	17.13	104.8	16.56
61.....	105.8	17.26	105.2	16.68
62.....	106.3	17.39	105.7	16.82
63.....	106.7	17.51	106.1	16.96
64.....	107.2	17.64	106.5	17.08
65.....	107.7	17.78	107.0	17.21
66.....	108.2	17.93	107.4	17.35
67.....	108.7	18.08	107.9	17.49
68.....	109.2	18.24	108.5	17.66
69.....	109.8	18.40	109.0	17.84
70.....	110.4	18.55	109.6	18.03
71.....	111.1	18.70	110.2	18.22

TABLE I B

AVERAGE STATURES AND WEIGHTS IN CENTIMETERS AND KILOGRAMS BY SEX, FROM BIRTH TO SIX YEARS; SMOOTHED FIGURES; WHITE CHILDREN

Age	White boys		White girls	
	Stature (centimeters)	Weight (kilograms)	Stature (centimeters)	Weight (kilograms)
Under 1 month.....	53.7	4.13	53.1	3.92
1 month, under 2.....	57.1	4.94	55.7	4.60
2 months, under 3.....	59.9	5.72	58.6	5.31
3 months, under 4.....	62.4	6.38	61.0	5.91
4 months, under 5.....	64.5	6.97	63.1	6.46
5 months, under 6.....	66.3	7.39	64.8	6.95
6 months, under 7.....	67.9	7.92	66.4	7.38
7 months, under 8.....	69.3	8.31	67.8	7.75
8 months, under 9.....	70.5	8.64	69.1	8.08
9 months, under 10.....	71.7	8.93	70.3	8.37
10 months, under 11.....	72.8	9.19	71.4	8.63
11 months, under 12.....	73.8	9.44	72.4	8.87
12 months, under 13.....	74.9	9.67	73.4	9.09
13 months, under 14.....	75.9	9.90	74.4	9.30
14 months, under 15.....	76.9	10.12	75.4	9.51
15 months, under 16.....	77.8	10.33	76.4	9.72
16 months, under 17.....	78.8	10.55	77.4	9.92

TABLE I B

AVERAGE STATURES AND WEIGHTS IN CENTIMETERS AND KILOGRAMS BY  
SEX, FROM BIRTH TO SIX YEARS; SMOOTHED FIGURES; WHITE CHILDREN—*Cont'd*

Age	White boys		White girls	
	Stature (centimeters)	Weight (kilograms)	Stature (centimeters)	Weight (kilograms)
17 months, under 18	79.7	10.76	78.4	10.14
18 months, under 19	80.7	10.97	79.3	10.35
19 months, under 20	81.6	11.17	80.3	10.55
20 months, under 21	82.4	11.36	81.1	10.74
21 months, under 22	83.2	11.54	81.9	10.92
22 months, under 23	84.0	11.72	82.6	11.09
23 months, under 24	84.7	11.89	83.3	11.25
24 months, under 25	85.4	12.06	84.0	11.42
25 months, under 26	86.1	12.22	84.8	11.58
26 months, under 27	86.8	12.39	85.5	11.76
27 months, under 28	87.5	12.56	86.2	11.93
28 months, under 29	88.2	12.73	87.0	12.11
29 months, under 30	88.9	12.90	87.7	12.29
30 months, under 31	89.6	13.08	88.4	12.46
31 months, under 32	90.3	13.24	89.1	12.63
32 months, under 33	90.9	13.41	89.8	12.79
33 months, under 34	91.5	13.55	90.4	12.95
34 months, under 35	92.0	13.69	91.0	13.10
35 months, under 36	92.6	13.82	91.5	13.24
36 months, under 37	93.2	13.95	92.1	13.39
37 months, under 38	93.7	14.08	92.7	13.53
38 months, under 39	94.3	14.22	93.3	13.67
39 months, under 40	94.8	14.37	93.9	13.82
40 months, under 41	95.4	14.52	94.5	13.97
41 months, under 42	96.0	14.68	95.1	14.12
42 months, under 43	96.6	14.84	95.8	14.26
43 months, under 44	97.3	14.99	96.3	14.39
44 months, under 45	97.8	15.13	96.9	14.51
45 months, under 46	98.3	15.26	97.4	14.64
46 months, under 47	98.8	15.38	97.8	14.76
47 months, under 48	99.3	15.49	98.3	14.87
48 months, under 49	99.7	15.59	98.8	14.99
49 months, under 50	100.1	15.69	99.3	15.11
50 months, under 51	100.6	15.79	99.7	15.23
51 months, under 52	101.0	15.90	100.3	15.35
52 months, under 53	101.5	16.03	100.8	15.50
53 months, under 54	102.1	16.16	101.4	15.64
54 months, under 55	102.6	16.30	102.0	15.79
55 months, under 56	103.2	16.45	102.5	15.94
56 months, under 57	103.7	16.61	103.1	16.08
57 months, under 58	104.2	16.76	103.6	16.22
58 months, under 59	104.7	16.91	104.1	16.35
59 months, under 60	105.2	17.05	104.5	16.49
60 months, under 61	105.6	17.20	105.0	16.62
61 months, under 62	106.0	17.33	105.5	16.76
62 months, under 63	106.5	17.45	105.9	16.89
63 months, under 64	107.0	17.58	106.3	17.02
64 months, under 65	107.5	17.71	106.8	17.15
65 months, under 66	108.0	17.85	107.2	17.28
66 months, under 67	108.5	18.00	107.6	17.43
67 months, under 68	109.0	18.16	108.2	17.57
68 months, under 69	109.5	18.32	108.7	17.75
69 months, under 70	110.0	18.47	109.3	17.93
70 months, under 71	110.4	18.67	110.2	18.22
71 months, under 72	111.4	18.78	110.5	18.31

TABLE II A  
AVERAGE WEIGHT FOR HEIGHT, BY SEX; WHITE CHILDREN<sup>1</sup>

Stature Centimeters	Boys		Girls	
	Number	Average weight (kilograms)	Number	Average weight (kilograms)
50.8.....	206	3.71	310	3.69
53.3.....	486	4.30	654	4.21
55.9.....	905	4.79	1,121	4.78
58.4.....	1,352	5.42	1,635	5.39
61.0.....	1,994	6.11	2,318	6.05
63.5.....	2,496	6.81	2,866	6.72
66.0.....	3,068	7.53	3,179	7.42
68.6.....	3,525	8.18	3,561	8.01
71.1.....	3,775	8.80	3,471	8.62
73.7.....	3,605	9.38	3,425	9.16
76.2.....	3,671	9.97	3,563	9.66
78.7.....	3,834	10.54	3,750	10.25
81.3.....	3,803	11.14	3,805	10.80
83.8.....	4,075	11.70	3,951	11.37
86.4.....	4,533	12.30	4,405	11.98
88.9.....	4,698	12.89	4,596	12.59
91.4.....	5,159	13.48	4,919	13.21
94.0.....	5,074	14.10	4,974	13.78
96.5.....	5,265	14.71	4,973	14.38
99.1.....	5,133	15.35	4,823	14.96
101.6.....	4,769	16.00	4,505	15.64
104.1.....	4,181	16.71	3,894	16.34
106.7.....	3,393	17.41	3,002	17.01
109.2.....	2,312	18.20	2,020	17.79
111.8.....	1,598	18.93	1,341	18.57
114.3.....	857	19.73	703	19.41
116.8.....	423	20.60	349	20.41
119.4.....	193	21.45	143	21.25

<sup>1</sup> The unit of grouping was the inch; the centimeters and inches show the mid points of the groups. Averages are not shown for statures under 20 inches nor for statures 48 inches or over, since the numbers of children of these statures were too small to afford satisfactory averages.

#### HEIGHT AND WEIGHT STANDARDS FOR CHILDREN

Nutrition work for children has been very extensively developed in recent years; but it has not as yet been subjected to critical tests. In most places this work has been based upon certain standards of height and weight, which, it has been assumed, indicate the healthy child. Children who are underweight for their age according to these standards have been usually assumed to be malnourished, and care has been directed to bring such children up to the standard. The tables most extensively used in this connection have been those recommended by the Child Health Organization of America.



TABLE II B  
AVERAGE WEIGHT FOR HEIGHT, BY SEX; WHITE CHILDREN

Stature (inches)	Boys		Girls	
	Number	Average weight (pounds)	Number	Average weight (pounds)
20.....	206	8.19	310	8.13
21.....	486	9.47	654	9.28
22.....	905	10.55	1,121	10.53
23.....	1,352	11.94	1,635	11.88
24.....	1,994	13.47	2,318	13.33
25.....	2,496	15.01	2,866	14.82
26.....	3,068	16.60	3,179	16.35
27.....	3,525	18.03	3,561	17.66
28.....	3,775	19.39	3,471	19.01
29.....	3,605	20.68	3,425	20.20
30.....	3,671	21.99	3,563	21.30
31.....	3,834	23.19	3,750	22.60
32.....	3,803	24.56	3,805	23.81
33.....	4,075	25.80	3,951	25.06
34.....	4,533	27.12	4,405	26.41
35.....	4,698	28.41	4,596	27.75
36.....	5,159	29.72	4,919	29.13
37.....	5,074	31.09	4,974	30.67
38.....	5,265	32.44	4,973	31.71
39.....	5,133	33.84	4,823	32.99
40.....	4,769	35.28	4,505	34.49
41.....	4,181	36.83	3,894	36.02
42.....	3,393	38.38	3,002	37.49
43.....	2,312	40.13	2,020	39.23
44.....	1,598	41.73	1,341	40.94
45.....	857	43.50	703	42.79
46.....	423	45.41	349	45.00
47.....	193	47.29	143	46.85

In the use of these tables, most nutrition workers have forgotten the limitations of which the authors themselves were well aware. For example, these standards reflect conditions primarily among native born children of native parents. They were never intended to test the degree of under-development of children of foreign stocks, especially Italian and Jewish children, among whom so much nutrition work is done. Children of these race stocks are uniformly shorter and lighter than are children of native parentage. There is, in fact, much variability in the heights and weights of the children of the various races, and such standards as are used should take the racial factor into consideration. Nutrition workers should develop adequate measures of the height and weight of healthy children in the particular race groups among whom they work. This will avoid much confusion and will result in considerable economy of effort; because many children who are now classed as malnourished would, on truer standards, be found to be well within the limits for healthy children of their race.

In addition to the racial factor, there is another and perhaps more important element which has been very much overlooked in nutrition work, namely the allowable normal departure from the average height and weight for age irrespective of race. Healthy children of whatever nationality vary considerably from the average in height and weight. Thus, the weights of healthy children of seven may range from 37 to 62 pounds and those of boys of fourteen all the way from 78 to 171. Even if we limit these boys to those who are 60 inches tall, we will find variations from 80 to 125 pounds, with the average weight at 97.5 pounds. There is, in other words, a "safety zone" on either side of the average which includes well nourished children. The important requirement in this work is not so much to know the average weight for children of the various races but the limits of variation which will include the healthy children. It has been assumed that any weight more than 7 per cent below the average establishes malnutrition and that an excess of 20 per cent above the average is an indication of obesity. It is quite clear that 7 per cent is not a safe lower limit until this has been established by the actual weights of children who are clearly determined to be malnourished on evidence other than weight.

It should be remembered that underweight up to a certain point is in itself not a defect. Among adults, underweight is indeed a distinct advantage at certain ages. Thus, if longevity is a good test of fitness, underweight even up to 50 pounds below the average is an advantage among persons forty-five years of age or over. The lowest mortality at certain age-divisions is not among those of average weight but among the so-called underweights.

It is, therefore, important to emphasize the need for more exact standards in carrying on nutrition work, especially in our large cities where so much is done among children of foreign extraction. And, in such work, more discretion should be used to exclude children who, although somewhat below table weight, are nevertheless, healthy; that is, free from other symptoms of malnourishment. Underweight itself is not a final criterion of malnutrition.

*Statist. Bull. Met. Life Ins. Co., 1821, II, No. 3, 5-6.*

#### CHILD WELFARE

*United States:*—In the United States in 1919 one mother died for every 135 babies born, and every eleventh baby born died before he was a year old. That these rates are excessive is shown in "Save the Youngest," a bulletin issued by the U. S. Department of Labor through the Children's Bureau, and just revised to compare the latest rates for the United States with those for foreign countries (June 1, 1921).

Six countries are shown to have a lower infant mortality, and 16 in a group of 17, a lower maternal mortality, than the United States. Not only do we lose more mothers in proportion to births than practically

any other civilized country, but we apparently lose more on an average each year than the year before. Whereas in other countries there has been a decrease in the death-rate from childbirth, the rate in the United States rose from 6.1 per 1,000 births in 1915 to 6.2 in 1916, 6.6 in 1917 and to 7.4 in 1919. Moreover, in this country there is no appreciable decrease in the proportion of babies who die from causes largely connected with the care and condition of the mother.

Experience has proved that thousands of deaths of both mothers and children could be prevented every year by public measures for the protection of maternity and infancy. In New York City, among 4,496 mothers who were supervised by the New York Maternity Center Association before and after the birth of their babies, the maternal mortality rate was less than one-third the rate of the United States and the rate for deaths in early infancy was less than half that for the city as a whole. In other cities of the United States and in foreign countries the institution of infant welfare measures has been followed by greatly decreased rates.

Measures which have proved successful in preventing this waste of life among mothers and babies include the following: Prompt and accurate birth-registration, health centers, public health nurses, special clinics, trained attendance at childbirth, adequate hospital service, education of the mother in maternity and child hygiene, and education of the general public in the significance of a necessity for maternal and infant health.

*Europe:*—A marked tendency to aid child-welfare work by State funds is shown in another report, on "Infant Welfare Work in Europe," issued by the U. S. Department of Labor through its Children's Bureau (May, 1921). This report gives an account of work in Great Britain, Austria, Belgium, France, Germany and Italy.

In all these countries legislation designed to reduce infant mortality has been in force for a number of years, forbidding the industrial employment of mothers before and after childbirth. All important European countries have also made provision for maternity insurance. But experience shows that this is not sufficient and more direct and special measures to save the lives of babies have received government encouragement and aid chiefly during the past decade. Appropriations are being made for the support and extension of baby health centers and home visiting, notably in Great Britain, France, Belgium, and Germany. Since 1914 England has been making grants of 50 per cent of approved expenditure on infant-welfare work done by either voluntary agencies or municipal or county authorities. The scope of these grants has been enlarged year by year until practically every aspect of infant and maternity welfare is now covered. In France subsidies up to 20 per cent of approved outlay are given to infant welfare organizations by the Government. In 1919 Belgium passed a bill providing for government appropriations to cover half the cost of health center, and other infant welfare activities. In 1918-19 Great Britain spent 258,500 pounds of govern-



ment funds on infant welfare, and in 1918 France appropriated 650,000 francs for infant welfare work in addition to three million francs for nursing premiums and maternity benefits. State aid has resulted, according to the report, in a rapid expansion of work in behalf of mothers and babies. It has succeeded in bringing about also coördination of all agencies in this field and in exacting higher standards of work.

*New Zealand:*—Over one-fourth of the babies born in New Zealand, the children of well-to-do as well as of poor parents, are reached by the infant welfare measures in force in that country. How effective these measures have been in saving the lives of babies is shown in a striking manner in a summary of a forthcoming report, "Infant Mortality and Preventive Work in New Zealand," just made available by the U. S. Department of Labor through the Children's Bureau (June 13, 1921).

In a period of 45 years, according to this report, the infant mortality rate in New Zealand has been more than cut in half until now it is the lowest rate of any country in the world. During the last ten years the rate of decrease has been almost double what it was for the preceding decade. Within 15 years the mortality from gastric and intestinal diseases, the most deadly of all diseases to babies, has been reduced four-fifths. The rate of decrease in respiratory diseases during the past 15 years has been over three times the rate of decrease during the preceding twenty. There has been a slight decrease during the past few years even in deaths from diseases of early infancy.

While a mild climate, and favorable housing and economic conditions, the report points out, may explain the low rate in New Zealand, these factors alone can not explain the decrease which has taken place. Beginning in 1901 and covering the period in which there was the greatest decline, the government has given special attention to the problem of providing suitable maternity and infant care. Among important public measures described in the report are regulations for the training and practice of nurses and midwives, the establishment of state maternity hospitals, and more careful supervision of homes in which children are boarded out. The government also subsidizes the work of the Royal New Zealand Society for the Health of Women and Children. One of the most important activities of this society is an extensive system of baby health centers at which specially trained nurses give free advice and instruction to mothers.

*Child Labor:*—The processes of federal law administration have brought automatically into view the vicious circle of child labor, illiteracy, bodily feebleness and poverty. This statement is made in a report on the "Administration of the First Federal Child Labor Law" issued by the U. S. Department of Labor through the Children's Bureau, May 28, 1921. As a necessary aid in the intelligent enforcement of this law a body of important material was collected showing the conditions under which children go to work.

In 5 States it was necessary for the Children's Bureau to handle directly the inspection of certificates and the issuing of certificates.

During the 9 months in which the first federal law was in force over 25,000 children in these 5 States applied for certificates of age. Nineteen thousand, six hundred and ninety-six certificates were granted to children between 14 and 16 years of age, almost as many to girls as to boys. Less than one per cent of these children could furnish birth certificates as evidence of their age, and only two per cent offered baptismal certificates. Two-fifths submitted Bible records and over one-fourth life insurance policies. About one-fourth of the children, however, could furnish no documentary evidence, and had to secure a physician's certificate to show that they were over fourteen years old.

Many of the children who were found underweight when examined by a physician had been working in the mills for several years. Some gained quickly when taken out of the mill and put on a better diet. With others it was difficult to reach even the low standard which the physical requirement required. Many of the parents to whom physical defects in their children were reported were unable to pay for medical attention, and in most cases no public clinics were available to lend assistance.

## NATIONAL RESEARCH COUNCIL

### DIVISION OF MEDICAL SCIENCES

#### DIVISION OF ANTHROPOLOGY AND PSYCHOLOGY

#### CONFERENCE ON PROPOSALS MADE BY THE CHILD WELFARE SOCIETY AND THE WOMAN'S WELFARE ASSOCIATION

A conference under the joint auspices of the Divisions of Medical Sciences and Anthropology and Psychology to consider the offer of facilities for research by the Child Welfare Society and the Woman's Welfare Association was held at the National Research Council, Wednesday evening, January 19, 1921, at eight p.m.

#### PRESENT

G. W. McCoy, Chairman, Emile Berliner, Harry S. Bernton, Taliaferro Clark, Charles D. Easton, Emery Filbey, S. I. Franz, Aleš Hrdlička, George M. Kober, C. F. Langworthy, John T. Metcalf, Anna E. Rude, W. C. Ruediger, Mrs. C. W. Wetmore, Clark Wissler.

#### PROPOSALS OF THE CHILD WELFARE SOCIETY AND THE WOMAN'S WELFARE ASSOCIATION

The Chairman called on Dr. Bernton who presented the following outline of the work of the Child Welfare Society. The Child Welfare Society has been in existence in the District of Columbia for twenty years. Its chief aim is the conservation of child life. The Society is doing a splendid social service and has been largely instrumental in the reduction of infant mortality in the District. Dr. Bernton pointed out the many opportunities the Society offered for investigations covering the entire range of medical activities. The Society is not interested in the sick child which may be cared for in hospitals and dispensaries, but deals essentially with the normal infant. Here there is material that ought to be studied.

Last spring the Society took definite steps to inaugurate research. For example, the Society enlisted the interest of Dr. C. B. Davenport, who sent an assistant to carry on some work in eugenics. Dr. Watson also conducted some studies on the instincts of infants. The Society, however, has no funds for research. It has a budget of about \$30,000, \$15,000 of which is appropriated by Congress, the remainder is subscribed from private sources. These funds are needed for the social work and are not available to promote research. The Society is eager to undertake this work and asks those interested in child life to assist it. The Society has on its rolls about 3573 infants, under one year old. Last year, practically thirty-five per cent of the children born in the District were enrolled. An attempt was made last year to care for children of pre-school age (six years); the society has about 600 children of this age on its rolls. The Society also has a dental service which is offered to all children under six.

Mrs. Wetmore summarized the work of the Woman's Welfare Association as follows: The Woman's Welfare Association has not as long or as valuable a record as the Child Welfare Society. The Society is the outcome of a Woman's Evening Clinic that was carried on in a small way for seven years. There is in Washington a large class of women who will not and do not avail themselves of the service offered by the free clinics and yet can not afford the services of a physician. Thus many small ills do not receive the prompt attention they need. The clinic of the Woman's Welfare Association was founded to serve women of this description.

The Association has met with great encouragement. In the seven years of its existence roughly 25,000 women have been examined, averaging 400 a month. Mrs. Wetmore became president of the Association two and a half years ago and found that the women especially needed two things: a nursing and a recuperative ward, and instruction in hygiene for the women struggling along as best they could in ignorance of how to care for themselves. To this end it has bought a house and now has a nursing ward of ten beds for rest and recuperation and has installed a trained nurse as superintendent. In addition it has installed a gymnasium, hired a physical culture director, and founded a Good Health Club which now has 400 members.

The general scheme of the work and organization of the Association was laid before Washington physicians and as a result a medical board was formed, and also an advisory board, and it has secured the aid of 28 clinicians who maintain twelve clinics a week. The system is as follows: the women have a thorough physical examination; if the general examiner finds any difficulty they are passed on to the proper clinic, thus placing at the disposal of the working women of Washington the most approved scientific methods of treatment.

The chief reason for this work was a desire to accumulate scientific data in order to give them the best and most effective aid. A great deal of data on men were collected in the Draft. Data as to children were made available by the child welfare societies of the country. The Woman's Welfare Association wished to collect information as to what are the standards and needs of women in order that they may be raised to a high level of maternal, as well as general life efficiency. The Society is trying to work out a system by which knowledge on the subject of women's ills, the avoidance of difficulties by proper nutrition, etc., and how to teach women to bring themselves up to a high physical level shall be gained.



The Association is anxious to secure all the help and suggestions possible. It is found that seven out of every ten cases come to its clinics because of disorder of the feminine organs, the result of occupational strain or in many cases the result of carelessness and improper nutrition. This is where the Association can give its greatest aid and attain most knowledge. It is hoped that through the studies made possible by the Woman's Welfare Association there would be made available a really valuable amount of information on how to treat the average working woman.

Dr. Easton also discussed the work of the Woman's Welfare Association. The Woman's Welfare Association is conducting a rather unique clinic which differs very widely from any other clinical work. The Society has presented its plans to people interested in the work with the view to formulate a scientific program for utilizing the facilities offered by this organization. With this end in view they have consulted the two Divisions of the Research Council as to what are the proper and legitimate lines along which something worth while could be accomplished. Mrs. Wetmore has interested in the Society nearly every person in Washington who employs one or more women. One problem that should be studied is the question of occupational disturbances: for example, discover whether standing at their work is a factor in various women's complaints and whether these are preventable in large measure by proper physical training, posture, etc.

The Society has an up-to-date physical culture room in charge of a first class woman trained to the work. It has contact with a growing group of young women from all parts of the City, but no scientific use is made of the available material. It is hoped that with the advice and council of those interested both in the social and scientific side of women's welfare, that ways and means may be found for scientific use of this material. The Society has founded a department of industrial medicine to solve some of the fundamental problems as to what hinders most efficient work and health among young women. It is hoped that those present this evening who are interested in this work will point out ways of utilizing this material.

The Chairman asked Dr. Wissler to speak for the National Research Council. He stated that the first contact made with these organizations came through the Division of Anthropology and Psychology which became acquainted with the Child Welfare Society chiefly because some of the psychological members of the Division, interested in particular kinds of research with infants, found it possible to carry on some investigations there. The whole subject of scientific research as a background for orderly and proper procedure in child welfare was discussed before the Division and, as a result, a resolution was adopted which is quite pertinent to the business of the evening, and expresses the attitude of the Research Council to societies of this kind. Similar action was taken by the Division of Medical Sciences. As expressed in these resolutions the attitude of the Council is one of helpfulness. We believe that systematic research is necessary to the development of child and adult welfare work and that such research ought to be encouraged. The particular problem presented to us tonight is rather difficult and one which demands your earnest attention. These institutions offer certain facilities and opportunities for research in this very field. We have opportunities here of a material kind. I understand that certain rooms and laboratories, etc., in these institutions are available for research and it is the hope of these institutions that they be used. The problem before this conference is to devise ways by which research men in Washington may use these facilities.

## DISCUSSION BY MEMBERS OF THE CONFERENCE

Dr. Kober has watched the work of the Child Welfare Society for a number of years, saw many beneficent effects of that work, and took a strong interest in helping to secure Congressional support. Its success has certainly far exceeded expectations. The most convincing argument is always observation, as witness: the pre-natal work, the welfare stations, the babies and mothers religious in their attendance, the progressive improvement, and a most gratifying reduction in the infant mortality rates. From a practical point of view the results have been very beneficial. The work of the Society has improved greatly under the directorship of Dr. Bernton, who should also be congratulated on his vision in recently organizing a dental clinic for little children. It is his positive conviction that in the endeavors to secure improved power of resistance to disease, foundations must be laid not only in babyhood, but also in the pre-natal states. Good results have been obtained wherever such pre-natal care of mothers earning their living in industrial establishments has been attempted. Such care would tend to improve the racial stock of any country. The establishment of schools for girls between the age of 17 and 20 years to teach them how to become good housewives and mothers, could not fail to develop a strong, healthy, and virile race.

He is interested in the scientific aspect. It is a great pity that studies of value to the anthropologist are not carried on. We are, after all, a strictly composite nationality. Nearly every large American city affords opportunities for studies of children of a rather pure type and a study of the racial characteristics of the different European stocks and comparison with the composite mixtures of this country will undoubtedly be of great interest. Washington has a large proportion of negro population. These infant welfare stations have special days for the negroes and the attendance is equally gratifying.

With regard to what has been suggested by Dr. Eastman in the line of industrial hygiene for female wage earners, there is, of course, a very great need for the correction of physical defects that render industrial workers less efficient: flat foot and postural defects, for example. Many of the women so afflicted who come to the Association for relief, are not sick to the extent of requiring hospital care, but suffer from ailments that may be benefited by correction. It is certainly true that if all physical defects were corrected in early childhood we would have a more perfect and efficient nation. The findings of the Draft Boards have demonstrated that there is need for the prevention of permanent disabilities in childhood. He expressed the hope that the Council will do all it can to further and broaden the work of these two institutions and utilize the laboratories and material for scientific research. For example, with very little financial aid, Dr. Hrdlička could make really interesting studies in physical anthropology and publish them. Dr. Kober mentioned the existence of much unpublished anthropological data in university gymnasiums. These he thought should be made available by a suitable grant from the National Research Council.

Mr. Berliner, President of the Tuberculosis Association, said he was interested in assisting people to maintain and increase natural resistance to disease. He is interested in child welfare, because to build up a good race we must not only begin in childhood, but with the mothers. Direct interest in children has brought us in

close touch with the milk question and the question of vitamins. Mr. Berliner discussed the question of milk powder, giving a résumé of the processes of manufacture in cylinders and in vacuums. He also gave the results of experiments on twins with the use of cylinder process milk powder versus mother's milk. Apparently the cylinder made powdered milk is more nutritious. There is a serious aspect to this, because this experiment seemed to show that breast milk is not always best, due, no doubt, to physical condition or under nourishment of the mother. Therefore, one subject that should be studied is the question of vitamins in mothers' and babies' food.

Dr. Rude stated that the Children's Bureau recognized that there is a large fund of valuable material in the records of these organizations. The Bureau had recently been interested in finding out if the records of the Child Welfare Society were available for data in regard to a research problem contemplated by the Bureau. The limited staff of the Children's Bureau makes a definite offer of assistance impossible, but, of course, we are interested in the development of all welfare organizations, research, etc.

Dr. Hrdlička pointed out that the presentation of facts in connection with the Child and Women's Welfare Societies emphasized the many neglected opportunities and the importance of utilizing the great fund of information at hand and thereby rendering help to the community. But there is no one to do the work and no one to support it if workers were available. Conditions in scientific circles are such that because of the poor compensation and the poor prospects in life, no students are attracted. Men do not become anthropologists or comparative anatomists because they find better opportunities in other directions. Were the opportunities for investigation multiplied by the hundred, we should still stand paralyzed; we could not take advantage of them in a profitable way. One possible suggestion is for those interested in the work here discussed to find say half a dozen young physicians, because no other should undertake work in physical anthropology except graduate physicians, and the Smithsonian Institution will be glad to help them with anthropological training. Here however it will be well to note that work of this nature is not the work of a moment, it is the work of years. Even if the men can be found they will need continued support. And after the initial expenses means must be found for elaborating and publishing the results and making them available for practical purposes.

Doctor Langworthy stated that the Office of Home Economics has been carrying on research and collecting information concerning food, clothing, and household equipment and management. It is now in a position to discuss food selection in non-technical terms, on the basis of the five food groups into which all our common articles of food may easily be divided, and the approximate amounts from each group needed daily or weekly by the family or the individual. The Office maintains a laboratory equipped for careful experimentation in methods of food preparation. The information gathered by the Office is made available for the practical use of Extension workers who carry it directly to the women and children in the rural homes. Popular publications available for free distribution deal with the choice, preparation, and nutritive value of foods, with the selection and care of clothing and household equipment, and with simple, trustworthy methods of housework. As far as special work for children is concerned, the Office of Home Economics has dealt



only with normal children above the age of infancy, and has prepared a popular bulletin on "A Sensible Diet for a Child" and another on "School Lunches." These in a sense begin where the publications of the Children's Bureau leave off. The time is ripe for more general work on food selection, for practicable methods of popular, non-technical instruction have been worked out, and many people now realize the value of knowing what constitutes a proper diet. Such a group as the one represented this evening could do much to help teach people how to feed themselves. Many of the ills of life come from the neglect of the simplest things. To bring together reliable common sense information about the simplest things of life that concern every person and family and formulate them for reasonable instruction; leaving out all fads and nonsense, would help future generations.

Mr. Filbey said that the Junior Employment Service is interested in the researches here proposed from a somewhat different point of view from those presented. The Service deals with young people between legal working age and twenty-one. The Service is cooperating with school systems in twenty-one cities and supervises the early working experience of young people. Reliable information is being gathered to be passed on to these boys and girls and to aid them to make their early employment adjustment. It is for this reason we are interested in researches which will bring to bear reliable racial characteristics information. The Service is interested in the effects of early employment, and, from the point of view of this conference, in the effects of early employment on girls and women, because of its reaction on motherhood. Any information that may be made available would aid us in passing on needed information to these young people and in turn aid them in the control which is fundamental in controlling the kind of situation you meet in your clinics.

Dr. Metcalf stated that he would not add anything to the discussion at this point except to express his interest in the work outlined. The most valuable way in which the Department of Psychology at George Washington University could cooperate with the work of these agencies would probably be along the lines of mental tests.

Dr. Franz expressed the opinion that primarily this conference need not decide whether or not there are any problems that need scientific investigation. That is definitely known. There are more problems than we can investigate. The whole matter seems to resolve itself into just two things: personnel and money. For example, in contradistinction to the view expressed by one of the other speakers, he was certain that if twelve to fifteen thousand dollars were made available for investigation in anthropology, an anthropologist could be found in this country to do work. His preference, however, is to put money into men rather than into topics. Numerous topics and problems suggest themselves, but they require men, and money. In connection with the suggestion of one of the previous speakers dealing with possible cooperation in psychological investigation a problem immediately suggests itself—the determination of mental-test norms for women. A recently published work on the delinquent women at Bedford Hills and elsewhere points to the fact that we have no norms on women for comparison of normal with delinquents. Here is a problem that someone might be persuaded to investigate at little expense in connection with women's clinics. It should, however, be emphasized that what should be decided here is not so much individual problems, but we should recommend the utilization of these agencies in such ways that some individual, or individuals, can be induced

to give financial assistance to some investigators of particular problems. Everyone here is willing to cooperate. The fundamental thing is to get the money, and the men with ideas can be found.

Dr. Ruediger concurred with Dr. Franz's statement of the case. We have opportunities, but no definite recommendations as to what to do with them. In a matter like this it is necessary to have problems and people to conceive them. The person to work out a problem is the one who has conceived it clearly. In the first place you must have a scientific expert interested in the problems pertaining to that field. The proposition here is as yet too indefinite. The problem is how to finance someone in each one of the fields mentioned. George Washington University would be delighted to have its Department of Psychology cooperate in any way possible with the Child Welfare Society.

Dr. Clark outlined a few important problems the solution of which could be profitably undertaken. These two organizations present fertile fields of inquiry and have come to the Council, stated their problems, and asked for assistance. The Council offers its advice but has no money to pay personnel. The question resolves itself into this: in each field there are certain major problems which should be inquired into. How shall we go about the solution of this problem? For instance, a very fertile field of study and inquiry in psychology is the problem of faulty habits of thought and behavior. To recognize these tendencies and to advise methods for combating these faulty habits of thought and behavior, we must have those who are trained and skilled. Again there is study of the mental status of delinquents who are feeble-minded or with defects in the emotional field. Tendencies early manifested by children of this type allowed to continue, become crystallized and nothing can be done for such children.

If we pass into the field of nutrition we find a wealth of problems. We do not know what is the proper standard or index for nutrition. We have tables of standards of nutrition. Have we followed the right road in arriving at these standards?

A very significant fact touched upon is that of faulty posture. It is important to study means of overcoming faulty posture to bring the body back to proper vim and tone and overcome the tendency of the various organs to relax. These things must be worked out properly by a system of rest, by proper food, and proper living. The only possible way in which this conference can be helpful is for the different societies to come before it with a definite problem and ask for its combined wisdom in adopting a line of investigation and procedure.

Dr. Wissler stated that the purposes of this conference from the point of view of the Council was to answer two or three questions which have, in a way, been answered. First, are there research men in the City of Washington actually engaged in problems that could be solved by the use of the facilities available in these institutions? This question has been answered, in a way. While some use can be made of the facilities offered, it is not clear that anyone here present has a problem upon which he is working energetically and actively which could be better solved by the facilities offered by these institutions than by the facilities which he now has. It remains to be seen if there are other investigators in the City who are interested. Second, is it possible for research men in Washington to make immediate use of these facilities? As I see it the real problem, irrespective of raising money for research, is, where are there men in Washington who are at work upon problems which they

can handle more effectively through these institutions? The Council is ready to do what it can to bring them into contact with these institutions.

The other point to be considered here is whether in your opinion it is feasible or worth while to go to the trouble and expenditure of time and energy to formulate a research program that could be carried out in these institutions, provided financial support is found. If you feel that it is worth while, then I am sure Dr. McCoy is willing to try to formulate such a plan. But above all, it is necessary to bring into contact with these institutions men who are actually engaged in research bearing upon welfare problems.

Dr. Berliner pointed out that these questions of child welfare and women's welfare are national and not local questions and should engage the government of the United States. He urged that they be so considered and that Congress should be asked for a special appropriation.

In reply to this statement by Dr. Berliner, Dr. Kober stated that it was his experience that it takes a great deal of pioneer and preliminary work to induce the Government to finance the study of problems such as this. He suggested that even though the National Research Council is necessarily handicapped for funds, some part of the available funds might be appropriated for purposes of importance such as this. When it is generally recognized that, the conservation of the vital assets of the nation are perhaps of the greatest economic importance, then the Federal Government or private foundations may take up the work. In the meantime, pioneer work can and must be done on a modest scale to convince the government or great benefactors of the importance of the work and to supply adequate funds.

Dr. McCoy stated that the time of research workers in government service is fairly well occupied. Yet, some Government research workers have problems that might be solved more readily by working in these institutions. The Hygienic Laboratory has one or two problems to whose solution the facilities of the Child Welfare Society would lend themselves very well. The Hygienic Laboratory, for example, will take into serious consideration the possibility of utilizing these facilities. The question before us is how many see an opportunity in the facilities offered by Dr. Bernton and Dr. Easton?

Dr. Easton speaking from the point of view of one who is in close touch with the work of the societies suggested the following: A certain individual comes into one or the other of these clinics, receives a physical examination, is fed, etc. We find a case that would interest Dr. Franz, for instance. Could we not call it to his attention? The men who discussed this cooperation last year thought they had a proposition that could be carried out. If these cases could be thoroughly gone over that might awaken the spirit of investigation in the minds of someone. We have got to have a group of men to work out these various problems.

To the question from Dr. McCoy as to how long a time the society had the average child under observation, Dr. Bernton replied that until recently until two years, but at present until six years of age, thus offering any particularly interested agency an opportunity to continue to follow a child after that through his entire school life. There are three children's clinics, twenty babies' clinics, and two nutrition classes. The society has 600 children on the rolls. The Society is confronted with the difficulty of interesting the average mother in having a child examined whom she thinks well.



Mrs. Wetmore asked if as a result of the conference whether it might not be possible that a sort of board for consideration of these matters be formed. Something should be worked up by this conference which represents so many influential lines of thought. The general feeling of the conference seems to be that it would be desirable to study the question of child and women's welfare, especially along the lines of maternal efficiency. If this conference could formulate a statement of what they thought would be worth while to present with a request for support to the Foundations, such as the Rockefeller Foundation, it will accomplish something worth while.

The Chairman asked whether it would not meet the situation to appoint a committee to formulate a resolution to be later submitted informally for suggestions and criticisms to the group.

Dr. Berliner again brought up the question of the National scope of the enterprise. However, the Chairman pointed out that to receive congressional support would require so much educational work and take so long that it would put the thing off indefinitely. The Research Council has been able to secure financial support for some other activities and it might be quite possible to secure financial support for some of the problems that could profitably be studied at these institutions, unless it is felt that there is a likelihood that Congress might give some support.

Dr. Kober stated that to secure Congressional support would take a long period of time and that it would be better to secure even a modest sum from some other source to put into use with the cooperation of existing agencies. For instance, in psychology Dr. Franz may be able to lend a helping hand in training some of the medical men connected with these institutions, Dr. Hrdlička within a few months could train some of these men to do good work in physical anthropology.

Dr. Hrdlička stated that in the work discussed there certainly are problems in which anthropology could be of assistance. In every case that comes under the influence of these organizations, the first question is, is this Being normal? A question which cannot be settled without definite medical and anthropological standards, without subjecting the person to a careful medical and anthropological examination, supplemented by proper measurements. If you will have trained physicians who will be able to do this, they will point out what is wrong with your subject, which will open a way to a correction of the trouble. There is where the assistance of anthropology will be of practical value. Without due anthropological training the examining physician is handicapped and could hardly be fully effective.

Mrs. Wetmore repeated her request for a resolution to be presented to the various Foundations.

Dr. Franz asked whether or not the resolution which was adopted by the Division of Anthropology and Psychology would not be satisfactory for that purpose if the wording were changed to include the personnel of this conference.

Moved, that the Chairman and Dr. Wissler revise the resolution in conformity with the previous discussion and present it informally to the members of the conference for approval.

Adjourned.

The resolution was formulated and submitted to the members of the Conference by the Chairman and was revised as follows:

**RESOLVED:**

1. *In view of the fundamental value and the great need of correct information about the principles involved in the conservation and improvement of child life and the health and efficiency of women and in view of the existence of many interests and agencies which approach this problem from the practical side, this conference recognizes the pressing need of the scientific investigation of basic facts and principles in this field and urges philanthropic interests and organizations to throw their energies in large part into scientific investigations of physical and psychological problems for the purpose of laying foundations for substantial and permanent progress.*

2. *That this conference expresses its appreciation of the proposals made by the Child Welfare Society and the Woman's Welfare Association to place their equipment and facilities at the disposal of such research workers as may be expected to contribute to progress in the above-mentioned fields, and feels it to be incumbent upon the agencies and individuals interested in such problems to encourage the best use of the opportunities thus afforded.*

3. *Finally, this conference recognizes the great research value of the laboratory facilities and materials made available in these two institutions and expresses the hope that financial support may be found to inaugurate these investigations without undue delay.*





## LITERATURE.

### GENERAL

LA TERMINOLOGIE DES SCIENCES ANTHROPOLOGIQUES. By Halkin (Jos.)—*Rev. Anthropol.*, 1920, XXX, pp. XXIII-IV.

An attempt at a classification and definiton of the various branches of Anthropology.

LES SCIENCES ANTHROPOLOGIQUES. By Fraipont (Chas.)—*Rev. Anthropol.*, 1920, XXX, pp. XX-XXII.

A proposed classification and definition of the different branches of Anthropology. Author recognizes two large sub-divisions—the biological and the social; and attempts the difficult task of classifying the activities under each of these headings.

INDIVIDUALISME EXPÉRIMENTAL. By Papillault (G.)—*Rev. Anthropol.*, 1920, XXX, 145-164.

Philosophy. Also a dissatisfaction commenced to be shared by many, with present stagnant state and banal procedures of Anthropology. Remedy—concentration of attention on concrete individualities. This however, is but an idea; what Anthropology really wants are new stars to follow, not ideas.

ANTHROPOLOGY AND WAR. By Read (Hercules)—*J. Anthropol. Inst.*, London, 1919, XLIX, 12-19.

Address of a general nature. Points out the eugenic opportunities of anthropology.

BIOLOGY AND WAR. By Pearl (Raymond)—*J. Wash. Acad. Sc.*, VIII, No. 2, June, 1918; repr. 20 pp.

"While war is a biological business to the problems of which the trained biologist could much contribute, it is not an absolute biological necessity. Nations neither lose nor gain biologically by war. But this does not mean that wars must not and will not be fought. . . . Wars will occur in the future as they have in the past until such time as civilized man has become a different kind of animal than he now is. . . . A nation which would systematically and thoroughly investigate such matters as what sorts of men, physically, psychologically and morally, make the best fighters; what biological conditions, including internal states, environmental conditions in and behind the lines, conduce to most efficient fighting; how fighters should be fed to obtain the best results; and other like problems, would be in an extremely

superior position in any conflict with a group not possessed of definite scientific information on these points."

ADDRESS TO THE ANTHROPOLOGICAL SECTION, BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. By Pearson (Karl)—Cardiff, 1920, 8°, 17 pp.

The author, condescending for once and admirably to plain language, expresses general dissatisfaction with the present state of Anthropology. He quotes the Germans to the same effect and could have readily extended his supporting line by many others. Where was Anthropology during the War? How is it helping the State? Why does it not progress and assume the foremost place among sciences that rightly belongs to it?

Anthropology must turn to the problems of racial efficiency, race psychology, to the task of making every individual efficient both through Nature and by Nurture. For these purposes we need Anthropological Institutes, with "a new conception of the range of problems to be dealt with and a new technique. From such schools would pass out men with academic training fit to become officials, diplomatic agents, teachers, missionaries and traders, in Europe, Asia and Africa; men with intelligent appreciation of and sympathy with the races among whom they were to work.

"But this extra-State work, important as it is, is hardly comparable in magnitude with the intra-State work which lies ready to hand for the Anthropological Laboratory that has the will, the staff and the equipment to take it up efficiently. In the present condition of affairs it is only too likely that much of this work, being psychometric, will fall into the hands of the psychologist, whereas it is essentially the fitting work of the anthropologist who should come to the task, if fitly trained, with a knowledge of comparative material and of the past history, mental and physical, of mankind, on which his present faculties so largely depend. The danger has arisen because the anthropologist has forgotten that it is as much his duty to measure the human mind as it is his duty to measure the human body, and that it is as much his duty to measure the functional activities of the human body—its dynamic characters—as its statical characters. By dynamical characters I understand such qualities as resistance to fatigue, facility in mental and physical tasks, immunity to disease, excitability under stimuli, and many kindred properties. If you tell me that we are here trenching on the field of psychology and medicine, I reply: Certainly; you do not suppose that any form of investigation which deals with man—body or mind—is to be omitted from the science of man? If you do you have failed to grasp why anthropology is the queen of the sciences. The University anthropological institute of the future will have attached to it a psychologist, a medical officer and a biologist.

\* \* \* \* \*

"I lay stress on the association of the anthropological institute with the university, and the reasons for this are manifold. In the first

place every science is stimulated by contact with the workers in allied sciences; in the second place the institute must be a teaching as well as a researching body, and it can only do this effectively in association with an academic centre—a centre from which to draw its students and to recruit its staff."

As to methods in Anthropology of today, "*quot homines, tot sententiae*." "Give anthropology a technique as accurate as that of physics, and it will forge ahead as physics have done, and then anthropologists will take their due place in the world of science and in the service of the State."

The present "condition of affairs must not continue; it is good neither for anthropology, nor for the universities, nor for the State if this fundamental science, the science of man, remains in neglect. It will not continue if anthropologists pull together and insist that their problems shall not fail in utility, that their scientific technique shall be, up to date, and that anthropological training shall be a reality in our universities—that these shall be fully equipped with museums, with material, with teachers and students."

In all of which there is much to reflect upon, but also much undeserved for the past, and even dangerous for the present. What Anthropology needs above all is a bevy of new leaders of the first class, a new brood of Master Minds. But it is a good sign that discontent with the actual state of affairs is felt by so many of the workers in anthropology, including the mathematicians; it presages better conditions, and that without the need of impinging on the field of psychology or any other collateral brands of endeavor.

GALTON'S PLACE AMONG ANTHROPOLOGISTS. By Keith (Arthur)—*Eugenics Rev.*, 1920, XII, No. 1, 14-28.

An address of appreciation of Galton's work, which deserves to be read by every anthropologist.

#### EVOLUTION EARLY MAN

THE DIRECTION OF HUMAN EVOLUTION. By Conklin (E. G.), 8° N. Y., 1921, 274 pp. (Chas. Scribner's Sons, \$2.50).

Biology throughout shows lawfulness. A continuous line leading from amoeba to man, through prehistoric and historic times, gives science a basis on which to form deductions as to possible or probable future steps in biological progression.

The ape-like, stooping, prognathous, low-browed Pithecanthropus, with saddle nose, receding jaw, protruding supra-orbital ridges and blunt expression, is the first known link between non-human Primates and Man. *Homo neanderthalensis* stands about midway between the Pithecanthropus and the *Homo sapiens* of Cro-Magnon, with a well-arched forehead, prominent nose and chin, long soft hair and erect bearing. This progress covers a period from the Pliocene about 500,000



years ago to the Neolithic age around the Mediterranean, approximately 10,000 years ago. Even if these races should not be in the direct line of descent of recent man, it is safe to say that the human family has been distinct from that of the higher apes for half a million years at least.

Evolution is transformation, not new formation. The germ cells are, with their mutations, potentially immortal; the body however, the fluctuations of acquired characters, die. Diversity, seen in innumerable reactions towards the immediate and indirect environment, and adaptation, result in progress. Increasing bodily complexity, increasing intelligence and social organization, become apparent. But the furthest possible limits have in the main probably been reached. The hand, eye, brain may hardly become more complex or further adapted. Intelligence has not been changed as to grade during historical time, and the limits have seemingly been reached in the minds of the greatest of the races. The knowledge of and control over nature are increasing and have overcome savagery and barbarism. Not the individual man has become more perfect however, but society. The present-day lack of geographical and the breaking down of racial isolation will probably work against evolution of a still higher race and result in "Federation of the World." Disharmony in social progress arises from mixture of social and anti-social instincts; harmony rests on greater specialization and co-operation. Its foundations are laid in gregarious instincts "but upon these foundations human intelligence has erected that enormous structure which we call civilization." Biologically the physically fittest is the most viable, intellectually the fittest is the most rational, and socially he is the most ethical. Above all nations is Humanity. The world is safe for democracy which enters into every relation of man to man. It must be associated with high morality, desire of social order and justice. It does not mean equality of heredity, environment, possession, intelligence, usefulness or influence.

These are some of the main thoughts contained in the first two parts of the volume dealing with human evolution and evolution and democracy. The third part treats of evolution and religion. The conflicts between religion and science can be only those arising between faith and knowledge, emotion and reason. "The goal of science is mechanism, of religion spirit." Scientific or mechanistic explanation is never complete, although progress in human knowledge must go on the lines of slow and laborious methods of science. It classifies phenomena but offers no explanation beyond the laws it finds, nor of their purpose, and explains them as those of "nature"; while philosophy and religion maintain that nature is the greatest mystery. From Aristotle to Driesch and Henderson a teleological principle in nature, something beyond the inquiry of science, has been sought. Darwin has rendered the most remarkable service to the philosophy of biology in the reconciliation of teleology and morphology. The bodies of men must be improved by eugenics and euthenics, their minds through education, their morals through religion.

"The past course of evolution together with the evidences for teleology in nature are strong arguments for a plan or purpose in evolution, the ultimate unfolding of which is probably beyond our power to conceive."

Dr. Beatrice Bickel.

EVOLUTION AND THE FUTURE OF THE HUMAN RACE. By Dendy (Arthur)—*Eugenics Rev.*, 1921, XII, No. 4, 266-278.

Sound philosophy, or perhaps better, a sound high sense. "The great principle of evolution" as the author sees it "whether we regard the individual, the community or the race, consists in sacrifice and re-birth at more or less frequent intervals—sacrifice of all those accretions which have become effete or developed beyond the limits of usefulness, and re-birth by making a fresh start with a clean sheet. This applies to mankind today just as it has done in the past with the lower animals, but the great distinguishing feature of the human race is the power of foreseeing, at any rate to some extent, the future, and of deliberately choosing the path of progress. That power, however, is as yet but little developed. It must be developed by education, and, above all, if the real welfare of the great mass of mankind is to be attained, the ideals at which we aim will have to be very different from what they are at present. Otherwise much that is well worth saving will be involved in the general sacrifice and civilization will have to go back a long way indeed before it can make a fresh start."

NOTRE PRIMORDIAL APPAREIL DE LA VISION PREUVE DE L'ORIGINE ZOOLOGIQUE DE L'HOMME. By Mahoudeau (Pierre G.)—*Rev. Anthropol.*, 1921, XXXI, Nos. 1-2, 12-23.

The facts "show that we possess even today included in the complexity of our brain vestiges of an organ the primordial origin of which goes back to a geologic epoch anterior to that which saw the appearance of the most ancient protospine animals, precursors of the vertebrates. The pineal gland, a much atrophied survival of the first visual apparatus possessed by our ancestors, does not only furnish indisputable anatomical proof of the parentage of man with the entire series of vertebrates, but assigns to him also a primordial point of departure among the most simple of zoologic forms, the most inferior ones among invertebrates."

A SKETCH OF THE ORIGIN OF THE CEREBRAL HEMISPHERES. By Herrick (C. Judson)—*Journ. Comp. Neur.*, 1921, XXXII, No. 4, 429-454.

"In summary, it may be regarded as established that the terminal portion of the neural tube early in vertebrate evolution gave rise to two pairs of lateral evaginations in correlation with the differentiation of the two sense organs which serve as the most important distance receptors, namely, the optic vesicles and the olfactory bulbs. In the most

primitive living vertebrates almost all of the brain in front of the mid-brain is dominated by the olfactory system and the differentiation of this region in all higher forms appears to have taken place largely under the influence of various systems of non-olfactory fibers which have grown forward into this olfactory territory. Increasingly complex correlations of the various other senses with smell have involved the elaboration of separate correlation centers in the forebrain for each of these reflex patterns, different in each species of animal according to its mode of life. The diverse patterns of cerebral architecture exhibited in the vertebrate series are, therefore, structural expressions of these functional relationships, namely, the various parts played by the olfactory and the different non-olfactory sensory systems."

THE EVOLUTION OF THE HUMAN FACE, ESPECIALLY THE STORY OF THE EVOLUTION, FROM FISH TO MAN, OF THE LACRYMAL BONE AS ONE OF THE BONES AROUND THE EYE SOCKET. By Gregory (W. K.)—*Nat. Hist.*, XIX, 1919; repr. 5 pp.

"The series as a whole shows the dominating parts played in this evolution at first by the loss of the opercular bones following the loss of the gills; secondly, by the development of a temporal fossa and of a zygomatic arch in connection with the more efficient functioning of the jaws; thirdly, by the forward shifting of the orbits to obtain better vision; fourthly, by the final expansion of the brain case; and fifthly, by the retraction of the jaws beneath the brain case."

#### EUGENICS

HEREDITY AND EUGENICS. By Gates (R. Ruggles)—*Eugenics Rev.*, 1920, XII, No. I, 1-13.

"The problem of formulating laws which would foster an increase in the more efficient and desirable members in each stratum of society, would seem almost to surpass the wit of man, and so far as we know it has not yet been accomplished in any community. The task appears all the more appalling when it is remembered how frequently Parliamentary laws have an economic effect quite different from that anticipated or intended. Probably an intelligent and enlightened public opinion is more efficacious than any law that could be devised. And a large element of that enlightenment will consist in an understanding of the nature, the laws, and the ubiquity of heredity. However, an obvious negative measure which can be carried into effect is the prevention of reproduction on the part of undesirables such as the feeble-minded. As we have seen, such measures are necessary, not so much for the improvement of the race as for arresting its rapid deterioration through the multiplication of the unfit."

SOME BIRTH-RATE PROBLEMS (continued). By Darwin (Leonard)—*Eugenics Rev.*, 1921, XII, No. 4, 279-290.

Another of a series of excellent articles on eugenic measures by Major Darwin. In this address he discusses more particularly the agencies



to be applied towards the reduction of the relatively high birth rate of the less fit.

COMMONSENSE IN RACIAL PROBLEMS. By Bateson (W.)—*Eugenics Rev.*, 1921, XIII, No. 1, 325-338.

A somewhat satirical, spirited address, showing no special new paths, but stimulating introspection and reflection. Eugenics has no clear or easy path before it.

ON THE PHYSICAL EFFECTS OF CONSANGUINEOUS MARRIAGES IN THE ROYAL FAMILIES OF ANCIENT EGYPT. By Ruffer (Marc A.)—*Proc. Roy. Soc. Med.*, 1919, XII, 145-190, Repr., London, 8°, 1920, 46 pp.

Historical study of Egyptian rulers descended from marriages of brother and sister, fails to show either physical or mental degeneracy.

STERILIZATION OF DEGENERATES AND CRIMINALS CONSIDERED FROM THE STANDPOINT OF GENETICS. By Pearl (Raymond)—*Eugenics Rev.*, April, 1919; Repr., 8 pp.

"By way of summary it may be said, from the standpoint of the science of genetics, that, while compulsory sterilization is the only adequate means yet suggested for the prevention of the reproduction of the socially unfit, striking immediate results in the reduction of the number of degenerates and defectives are not to be expected to follow the inauguration of such a system. Many years must elapse before the proportion of hereditary degeneracy in the race could be substantially reduced. Known genetic principles demand that, *ab initio*, not only actual defective, but the parents of actual defectives, should be prevented from further reproduction. Further, the means of sterilization employed should be such as to ensure a permanent result. The difficulties, both social and genetic, which beset sterilization as a remedial eugenic measure are so considerable as to make one doubtful of its accomplishing much."

#### HEREDITY

INHERITANCE AND EDUCABILITY. By Tredgold (A. F.)—*Eugenics Rev.*, 1921, XIII, No. 1, 339-350.

Educability is the innate capacity of a child for education. A markedly abnormal educability is due to germ impairment. The important question is may it not also be augmented. The author believes it may. "There is now good reason for thinking that not only the glands of internal secretion, but many of the organs and tissues of the body, such as the brain and muscles, each produce their own specific secretion, which is essential to the well-being of the organism.

"Now there is not the slightest doubt that the germ plasm contains within it in some form or other representatives of all the organs and

tissues to which it will give rise when fertilized; and these representatives are known as 'determinants.' May it not be then that the specific secretion produced by each organ of the individual may have a selective action upon the corresponding determinant within his germ plasm, and by its nature or amount tend to increase the developmental potentiality of that determinant? To put the case in more concrete form may we not imagine that an increased development and activity of brain may be accompanied by an increased brain secretion which will so stimulate the corresponding germinal determinant as to increase its potentiality for growth? . . .

"The degree of educability varies in different individuals, and is due to a potentiality for mental development which is innate. The realization of this potentiality is dependent upon the stimulus of education and a favorable environment. Minor variations in educability are probably but manifestations of a tendency to vary which is universal, and are not pathological. A marked lessening of educability is probably pathological. It shows a tendency to run in families, and is best explained as due to an impairment of germ potentiality. This impairment results from the operation of devitalizing influences upon the germ plasm. There is reason to think that provided the germ plasm is healthy, the exercise of mind, continued generation after generation, may give rise to an increased educability in the offspring. Previous life conditions may thus explain the differences in educability occurring in different races and sections of mankind. Impairment of potentiality is a far more rapid process than augmentation. The former may take place in a few generations; the latter only occurs where the germ plasm is healthy, and many generations must elapse to produce any appreciable result.

"Let us now consider the practical bearing of all this. Nations cannot stand still. The law of the survival of the fit applies to them as to individuals, and they must either progress or retrogress. If a nation is to progress, it must develop and utilize to the full all its resources, and of these none are more important than the developmental potentiality of its citizens. . . ."

"The remedy lies in the revival of the aristocratic ideal: but not an aristocracy of rank or of wealth, an aristocracy in the true sense of the word, and consisting of all that is noble and capable in man, an ideal of the duty we owe to our children and to their posterity in preserving them free from any tainted admixture, an ideal of biological fitness and of being truly 'well born.' Which calls for careful selective education."

An excellent article.

INHERITANCE OF DEAF-MUTISM. By Hansen (Soren)—*Meddelelser Danmarks Antrop.*, 1920, II, No. 2.

In Denmark the number of deaf-mutes is estimated at between 2000 and 2500, and careful registration is being made of all the living cases, their relations and their antecedents. The author has made a selection

of these cases mainly for the purpose of discussing the practical aspects of deaf-mutism, and importance of segregation or otherwise.

On the theoretical side, the author indicates that deaf-mutism, in so far as inherited, is usually a recessive character, one case in particular (p. 193) furnishing an exact expression of Mendel's law. As in all other problems of heredity, however, reasoning from mere statistical data may be very misleading. Deaf-mutism is only one of several related organic defects, and the inherited weakness may show itself as mental deficiency or disorder in other sense-organs. Hence the necessity of obtaining complete family records. A case in point is the well-known fact that such organic disturbances occur more frequently in offspring of near relations (p. 192). This is not due to the consanguinity, as is commonly believed, but without doubt to the reduplication of a dormant weakness in the ancestral lines.

On the practical side Dr. Soren Hansen is against any drastic restrictions on the lives and intercourse of deaf-mutes. This organic defect is not in itself a danger to the community, and will remain in the community even should outstanding examples be sterilized. The proper treatment would rather be, to work against the tendency of affected persons to marry similarly affected. Separate small schools instead of large institutes, separation of the sexes after childhood, and careful tuition would seem to be the most rational procedures with this class of defectives.

HEREDITY OF EYE COLOR. *Eugen. News*, 1920, V, 96.

According to the *British Medical Journal* for August, '21, H. Bryn (*Tidsskrift for den Norske Laegeforening*, May 15, 1920) has examined 834 persons in two mountainous districts in Norway with respect to the color of their eyes. He found that if both parents and all the grandparents had blue eyes without any brown pigmentation, all the children also were blue-eyed. When both parents were blue-eyed while some of the grandparents had eyes with brown pigmentation, 10 per cent of the children had eyes with brown pigmentation while the rest were blue-eyed. When both parents had eyes with brown pigmentation, 25 per cent of the children were blue-eyed and the remainder had eyes with brown pigmentation. When one parent was brown-eyed and the other blue-eyed, the number of blue and brown eyes was equally divided among their children. When both parents had "mixed" eyes, 25 per cent children had blue eyes, 25 per cent brown eyes and 50 per cent "mixed" eyes. If both parents had blue eyes with a well-defined brown ring round the pupil, all their children exhibited the same type of "mixed" eyes.

A CASE OF INHERITED SYNDACTYLY IN MAN. By Hurlin (Ralph G.). —*J. Hered.*, 1920, XI, No. 7, 334-335.

A brief report on inheritance of limited syndactyly (webbed digits) through three generations.



## ONTOGENY

LE NOMBRE DES CHROMOSOMES CHEZ L'HOMME. By Winiwarter (H. de)—*Rev. Anthropol.*, 1920, XXX, pp. xxv-xxxii.

A critical survey of work done on the subject, with the conclusion that much that has been done so far is of an imperfect nature and hence inconclusive. His own investigations, on ample fresh material, have shown that: "Les spermatogonies renferment 47 chromosomes (les oogonies 48); les cytes I, 24, tandis que les cytes II sont de deux espèces, à 24 et 23 chromosomes, selon la présence ou l'absence de l'hétérochromosome. Dans chaque catégorie, j'ai répété les numérations une cinquantaine de fois et j'aurais pu compter des centaines de cytes I, par exemple, si ce travail eut été indispensable et—je l'avoue—si j'en avais eu la patience!" The question of the presence of a heterochromosome in man the author regards as settled in the affirmative.

L'EPOCA DI GENERAZIONE. By Boldrini (Marcello)—*Riv. di Antrop.*, 1919, XXIII, 3-56.

Author's studies confirm the existence in the human female of an annual period of optimum liability to conception; and it is possible that something similar exists also in the male in relation to his sexual functions.

GROWTH OF CHILDREN IN COPENHAGEN AND SOME DANISH PROVINCIAL TOWNS. By Hansen (H. J.)—*Meddelelser Danmarks Antrop.*, 1920, II, No. 2.

A further contribution to the study of the growth of children, a subject that has attracted so much attention in many different countries during the past generation. To begin with the author discusses the various factors influencing growth, and by the aid of the results of previous authors indicates the corrections, *e. g.* for seasonal variation, and for racial and economic conditions, which must be applied in order to obtain well-balanced conclusions. The material is large (about 10,000 children, p. 203), from Aalborg-Kolding (Jutland), Rudkøbing (Langeland) and Copenhagen. Minor inequalities in the grouping of the data from the different places are eliminated by taking the largest and most uniform, *viz.* the material for Aalborg, as the standard, and recalculating the numbers in each year group for the other places in accordance with that standard.

A general comparison of the growth (weight and height) in the four towns shows that Copenhagen and Kolding are above, Aalborg and Rudkøbing below the general average. Neither the density of the population nor the social-economic conditions can explain these differences, and the author concludes that racial type is the most important factor, *i. e.* the children on the whole take after their parents wherever they may be placed.

In regard to weight, these investigations confirm the fact that though lighter in the earlier years girls increase more rapidly than boys up to

10-11 years and are then heavier up to the 14th year, after which the boys again overtake the girls and from the 16th year onwards remain the heavier. The relative increase in weight is fairly regular from year to year, but with two periods of greater increase, at 7-8 years for both sexes, and again for girls from 10-13 years, for boys from 13-14 years. Similar results have been observed in other countries, though slight variations occur.

At every age a considerable amount of variation is found about the average weight and this variation expressed by the average deviation increases with age from about 8-9 to about 12-13% of the average weight. The normal weight at any age may be taken to lie within 15% of the average weight, and the boundary line between strong and weak children at 10% under the average percentage of healthy children.

The height increases in more irregular fashion than the weight. Girls are taller than boys at 6 years, but grow less in the following years up to the 11th when they again acquire a lead and retain it till the 13th year. At 9 years boys are about  $\frac{3}{4}$  of the adult height.

The general course of the growth in height and the average annual rate of growth in different countries are shown. At each age as well as on the whole the distribution of the variants about the average and the mean deviation are much less for the height than for the weight.

As to the relation between weight and height, girls are heavier than boys at 140-150 cm. (12-14 years), thereafter lighter. On the whole the weight and height increase almost uniformly together, but previous to the period of greatest growth in weight and height, there is a decrease in the height rate of growth, suggesting that an accumulation of material occurs preparatory to the ensuing greater increase. Among the older children the height is less variable than the weight due to the former being less influenced by the environment than the latter. As to their mutual relation, the weight appears to be dependent on the height to a great extent, whilst the height varies independently, increasing with the years though the weight may be the same. In other words, height is more a function of the race or family, whilst the weight follows the height and is more influenced by the conditions of nourishment and health.

GROWTH OF THE BODY IN GIRLS. By Westergaard (Harald)—*Mendelelser Danmarks Antrop.*, 1920, II, No. 2.

This brief study is based on material collected in the Jaegerspris Institution for girls. The observations contain quarterly measurements of height, weight and chest, extending over the period 1912-17. A summary of the observations is given with a grouping into 5 year periods. Where comparable the results are in agreement with other studies on Danish children.

The influence of the Institution on the growth is tested by comparing the measurements on entering with those of the succeeding quarters. For both weight and height the growth in a year is greater than the

expected (calculated from those more than a year in the Institution); the first quarter's growth especially is very pronounced. Thus, the conditions of the Institution cause an immediate improvement in growth and one even more marked in weight.

The derivation of the weight from the height by means of various formulae is considered, but the results do not agree well or uniformly with the observed weights. A much better result is obtained by taking the formula: weight equal to square of chest multiplied by height and a constant—the last being calculated from the totals; or two constants may be used.

Lastly, the condition of nourishment may be measured by Pignet's formula, the weight in kg. being contrasted with the difference between height and chest in cm. The smaller the value, the better is the condition of nourishment.

**KLIMA UND MANNBARKEIT.** By Steinach (E.) and P. Kammerer—*Arch. Entwickl. mech.*, 1920, XLVI, 391-458.

The authors' experiments on rats in artificial clima show that increased temperature (up to 35°C.) causes certain cells in the testes and ovaries to increase considerably. The latter increase exerts a direct influence on sexual characters. A large part of the paper is devoted to an attempt to show for man a direct correlation between temperature, on one hand, and puberty, fertility, primary and secondary sexual characters, and rate of growth on the other. In this rather complicated problem, temperature is considered to be not only dependent on latitude, altitude, and season, but also on atmospheric moisture, housing with artificial heat, occupation, and diet. The numerous conclusions of the anthropological chapter are mostly of a speculative nature.

A. H. SCHUFTZ.

**THE CLIMATE OF KOREA AND ITS PROBABLE EFFECT ON HUMAN EFFICIENCY.** By Van Buskirk (J. D.)—*Trans. Korea Br. Roy. Asiat. Soc.*, 1919, X; depr. 58 pp.

Korea has a "good, but only a second-rank climate. It lacks the tonic effect of 'weather' ozone and electricity, and is depressing in its steady temperature and high humidity."

**THE INCREASED COST OF LIVING AND HEIGHT OF RECRUITS.** By Heiberg (P.)—*Meddelelser Danmarks Antrop.*, 1920, II, No. 2.

It is an interesting question whether the scarcity and increased cost of food during the last few years has had any influence on the gradually increasing height of conscripts—a phenomenon noted some years ago. For this purpose the records for the years 1913 to 1919 have been compared, and the results are shown in tabular form. It appears from them that the increase in stature has been arrested, and that greater numbers of the subjects occur now in the size-groups below the 1913 average.



## VARIATION—BODY

THE HEIGHT-WEIGHT INDEX OF BUILD IN RELATION TO LINEAR AND VOLUMETRIC PROPORTIONS AND SURFACE AREA OF THE BODY DURING POST-NATAL DEVELOPMENT. By Bardeen (C. R.)—*Contributions to Embryol.*, No. 46, Ext. fr. Pub. 272, Carnegie Inst. of Wash., 1920, 483-554.

"The purpose of this paper is to illustrate the value of the height-weight ratio as an index of the proportions of the human body and to suggest the usefulness of this character as an important factor in coordinating investigations in the field of gross human anatomy." The conclusions of the painstaking and valuable study, are in brief as follows:

1. The height-weight index is altered by the changes in external form which characterize post-natal morphogenesis in all individuals, by "physiological age."

2. The height-weight index is influenced by sexual peculiarities of structure.

3. The height-weight index is influenced by inherited individual or racial peculiarities of structure which may manifest themselves at any period of the life-cycle.

4. The height-weight index is influenced by peculiarities of structure due to habits of living or to environment.

L'INDICE BARICO IN CERTI SEZIONI DI POPO LAZIONE E NEI DUE SESSI. By Giuffrida-Ruggeri (V.)—*Riv. di Antrop.*, 1919, XXIII, 91-99.

The author examines once more into the subject of the Height-Weight Index of Build, which he has called the *Baric Index* in 1918 (see this JOURNAL, 1920, III, No. 4, 489). He has now calculated this index from Livi's data of the heights and weights of Italian recruits and has found significant differences between the various districts in the Kingdom. He tries to decide whether the *Mezobary* found in the adult female depends on her low stature, and is inclined to believe that for certain human races it is rather a late tertiary sexual characteristic. As a general result it is found that the female sex has a relatively smaller weight than the male only from birth to the third year and at the time of pre-puberty, which covers other three to four years (10-13). In early youth for some years the two sexes have about the same relative weight, then the adipose tissue continues developing and establishes an excess of weight in favor of the female.

V. G-R.

PREDILECTION AND SAMPLING OF HUMAN HEIGHTS. By Boring (Edwin G.)—*Science*, Nov., 1920, N. S. LII, No. 1350, 464-466.

Author calls attention to a possible "artifact" in a curve showing the distribution of the stature of 221,819 men, measured for the Life Insurance Companies in the United States.

## VARIATION—SKULL

IL CRANIO FETALE ED IL CRANIO ADULTO (SVILUPPO E RAPPORTI). By Mazzi (V.)—*Arch. p. l'Antropol. e la Etnol.*, 1918, XLVIII, 56-123.

Proportionately to the adult skull, the fetal cranium has the cephalic index always higher; the frontal index lower; the length maximum shorter; the breadth maximum larger; the basion-bregma height slightly smaller; the diameter frontal minimum and the height of the frontal bone smaller; the biasteric diameter much smaller. The fetal skull, compared with the adult, is less developed in the anterior and posterior thirds, and more developed in its middle portion.

L'ALTEZZA DEL CRANIO CONSIDERATA QUALE CARATTERE SESSUALE SECONDARIO NEI DUE TIPI CRANICI BRACHI- E DOLICOMORFI. By Giuliani (L.)—*Riv. di Antrop.*, 1919, XXIII, 177-184.

The author finds that not only is the female skull on the average relatively lower than that of the male, but also that the relative difference is not equal in the two main types of crania, being less in the dolicho- than in the brachycephals.

DIE TOPOGRAPHIE DER ORBITA BEIM MENSCHEN UND ANTHROPOÏDEN UND IHRE BEDEUTUNG FÜR DIE FRAGE NACH DER BEZIEHUNG ZWISCHEN MENSCHEN- UND AFFENSCHÄDEL. By Bolk (L.)—*Verhandel. K. Akad. v. Wetensch.*, Amsterdam, 1919, XX, No. 5, 54 pp.

The author does not deal with measurements, but with "comparative topography" of the orbits, in other words with the various features and characteristics of the cavities. The results indicate in the main that the human orbits have not lost, but that those of the anthropoid apes have acquired, certain differential characters. It is not the human but the special anthropoid features that have developed secondarily. And "the characteristics of the orbital region which may be regarded as typically human, are of infantile—not to say fetal—nature." The human cranium is derived from a relatively short-faced (fairly orthognathic) form, such as occurs in certain lower catarrhine as well as platyrrhine apes. In studying morphological relations between man and the rest of the primates it is useless to compare fully developed skulls; the comparison should be applied to the various manifestations on the skulls during their growth.

THE PROCESSUS FRONTOSPHENOIDALIS OF THE ZYGOMA AND ITS BEARING ON THE CONFIGURATION OF THE ORBIT. By Oetteking (Bruno)—*Anat. Rec.*, Sept. 1919, XVII, No. 1, 25-31.

The author describes a special method for the comparative study of the frontosphenoidal process in lateral projection as well as in a transverse midorbital section. The examination of crania of three very different races (German, Eskimo and Negro) as well as those of a series of anthropoid apes, have shown two principal forms of the process: in

one of these (gorilla, orang) it is fairly straight, while in the other (gibbon, chimpanzee, man) it curves backward besides presenting different grades of recession. The transverse section shows a marked erection of the process in man.

THE SUTURA NASOFRONTALIS. By Oetteking (Bruno)—*Indian Notes & Monographs*, Mus. Am. Ind., Heye Foundation, N. Y., 1920, VII, No. 2, 51-85.

The article gives the results of a detailed study of the nasofrontal suture on 88 Indian skulls from San Miguel Island, California. The results show considerable variability. The forms found are classified into straight, curved, semi-circular, rectangular and angular. The author also compares the length of the nasofrontal suture with the interorbital breadth and with the minimum breadth of the nasal bones.

THE FOSSA PHARYNGEA IN AMERICAN INDIAN CRANIA. By Sullivan (L. R.)—*Am. Anthropologist*, 1920, XXII, No. 3, 237-243.

"On the basis of the material at hand it seems that the frequent occurrence of the fossa pharyngea is limited to that area of North America which is or was the home of the Uto-Aztecan linguistic stock." A special point the author wishes to make is that "such characters as the fossa pharyngea have a similar distribution to that of the cephalic index, stature, etc., and are of equal (?) value in determining the relationship of local groups."

#### VARIATION—THE SKELETON

ON CERTAIN ABSOLUTE AND RELATIVE MEASUREMENTS OF HUMAN VERTEBRAE. By Cyriax (E. F.)—*J. Anat.*, July, 1920, LIV, 305-308.

A series of measurements of (as far as could be ascertained) normal human vertebrae taken from 36 articulated and disarticulated skeletons and spinal columns, 9 dry preparations of vertebral war injuries and about 600 loose vertebrae; in all 1482 bones. The actual measurements taken were: The mesial anterior vertical diameter of the body; the lateral diameter of the body (in the cervical region this was measured just above its lower margin, in the dorsal and lumbar at the middle of the body, thus obtaining its minimum lateral diameter); the maximum diameter of the whole vertebra, i. e. the spread of the transverse processes; and the maximum antero-posterior diameter of the whole vertebra. The author's results "agreed fairly closely with those of Anderson and Dwight; in many cases they corresponded exactly and in many others differences of only 1 mm. were encountered. The only differences greater than 3 mm. were: 5 mm. as regards the lateral diameters of the bodies of the last two lumbar vertebrae, and 5 mm. as regards the transverse diameter of the whole bone in the fifth lumbar vertebra."



VARIABILITY OF THE SPINAL COLUMN AS REGARDS DEFECTIVE NEURAL ARCHES (RUDIMENTARY SPINA BIFIDA). By Wheeler (Theodore)—Contrib. to Embryol. No. 30, Ext. fr. Pub. 272, Carnegie Inst. of Wash., 1920, 95-107.

"The condition of incomplete closure of the vertebral posterior arches is present in the different regions of the spinal column in the following order of frequency: (1) First sacral: Adolphi 12 per cent, Frets 26 per cent, author 13.1 per cent. (2) Entire sacrum: Radlauer 500 cases, 5 per cent; Adolphi 292 cases, 3.08 per cent; Frets 750 cases, 2.0 per cent; Frets 528 cases, 1.7 per cent; Frets (Breslau Anatomy) 257 cases, 3.5 per cent. (3) Last lumbar: author, 2.3 per cent in 1,000 cases. (4) Atlas: author, 1.47 per cent in 745 cases."

This paper contains a number of other interesting observations and is well worth a perusal.

A CASE OF OSSIFIED COSTOCORACOID MEMBRANE FUSED WITH THE CLAVICLE. By Bayon (Henry)—*Anat. Rec.*, Sept. 1920, XIX, 239-240.

"The subject, a negro male, with excellent muscular development, presented, after reflecting the pectoralis major a quadrilateral plate of bone articulating with the sternum and extending lateralward to above half an inch from the coracoid process, to which it was united by a fibrous band. The bone was fused with the clavicle, which formed its upper rounded and expanded border; the subclavius muscle was absent and the pectoralis minor inserted at the distal end of the abnormal bone."

THE TIBIA OF THE AUSTRALIAN ABORIGINE. By Wood (W. Q.)—*J. Anat.*, 1920, LIV, 232-257.

This valuable contribution is based on 236 Australian tibiae which had been collected mainly in the northern territory. The average length of these tibiae (from the articular surface of the lateral condyle to the tip of the medial malleolus) was 38.0 cm., which is above the average of any other race investigated and very large in proportion to the average Australian body-height. The tibiae of the two sides were equal in length in only 7.6 per cent of the cases, the right tibia being more often the longer of the two. The epiphyses of the Australian tibiae are strikingly slender; the average transverse diameter of the proximal epiphysis is 6.9 and of the distal one 4.5 cm., the corresponding sagittal diameters are 4.3 and 3.4 cm. The intercondyloid eminence and the medial malleolus are longer than in European tibiae. The average enemic index of this series is 65.2, the average angle of retroversion 17°, and that of inclination 13°. These angles are very high when compared with other races. The high degree of retroversion is conditioned by the acutely flexed knees during rest. Retroflexion is comparatively rare in the Australian tibia. The average angle of torsion in the tibia is 17°, which figure is rather low. On the left this angle is usually much greater than on the right.

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## VARIATION—TEETH

TEETH OF CHILDREN IN COPENHAGEN SCHOOLS. By Orth (Fritz)—*Meddelelser Danmarks Antrop.*, 1920, II, No. 2.

This preliminary paper deals with some of the more prominent results of an extensive investigation into the condition of the teeth in Danish school children. Earlier investigations had been made along this line as long ago as 1894, but in 1914 the subject was taken up anew on a wider and more detailed plan. Nearly 12,000 children from 22 Copenhagen schools were examined, and other characters, such as color etc. noted as well as the teeth.

By comparison with the 1894 results the condition of the teeth in the Danish children has become distinctly worse; e. g. in the former year 84 out of 1000 boys and 69 of 1000 girls had quite sound teeth, while now the numbers are only 19 and 16 respectively. To eliminate possibility of chance errors, attention was subsequently directed more particularly to the first permanent molar, with a like result; in 1894 about 60% of these teeth were affected by caries, now about 75% (children of 12-13). There was still the possibility that this deterioration might be greater in Copenhagen, a dense center, than in the smaller towns, but available data from a country school confirm and even accentuate the greater general prevalence of decayed teeth at the present time.

DIMENSIONS VERSUS FORM IN TEETH AND THEIR BEARING ON THE MORPHOLOGY OF THE DENTAL ARCH. By Hellman (Milo)—*Internat. J. Orthodont. & Oral Surg.*, St. Louis, Nov. 1919, V, No. 11; Repr., 8°, 39 pp.

SUMMARY: "1. The tests made to ascertain whether there is any correlation between the size of the central incisors, based on individual and average dimension, and any particular form of the dental arch in the anthropoid apes, failed to prove the affirmative.

"2. The tests made to ascertain whether any correlation may be found in the dimensions of the central incisors and those of the first molars in the dentition of anthropoid apes having a like form of dental arch also failed to prove the affirmative.

"3. The difference in contour of the molar teeth of the gorilla, as compared to the other anthropoids, was found to have some bearing on the forms of dental arch in that genus; showing a probable generic difference in the anthropoid apes.

"4. The form and position of the canines and premolars in all anthropoids have a morphologic influence upon the outlines assumed by the various dental arches.

"5. Evolutional processes influencing such modifications as number, form, position and occlusion of the teeth, constitute a noteworthy factor in the establishment of form in the dental arches not only of the various placental mammals in general, but also of the apes and man.

"6. The forms of both the upper and lower dental arches in the anthropoids in the same individual *may conform* to the one outline but in the greater percentage of cases *they differ*.

"7. This difference may be due to a fundamental difference in the pattern of the teeth in the two jaws, as well as to the adherence to the primitive position of the molar teeth in the upper jaw.

"8. The extreme diversity in form of the human dental arch fails to obscure similar conditions as in the anthropoids. Thus, the difference in tooth pattern in the two jaws, primitive position and occlusion, also produces in man a difference in the form of the two dental arches constituting one denture.

"9. The incisor occlusion in the human skulls examined, like that in the ape, is of a two-fold character. It may be in an overbite or edge-to-edge relation. And also that this is found to be in association with certain races more than with others. Thus the Indians and Eskimos exhibit an edge-to-edge occlusion, while the whites and Hindoos a moderate overbite, reaching an extreme condition in the Mongolians.

"10. And last, owing to the tendency of some races to exhibit certain associations with particular form of other features, as of head, nose, eyes, etc., it may eventually be proved that besides other factors, racial characters may also stand in close relationship to the morphology of the dental arch. This, however, requires considerably more study, and will depend upon further investigation of this problem to reach a stage in which such conclusions may be arrived at with more certainty."

THE FATE OF THE FIRST MOLAR. By Butler (H. B.)—*Public Health Rep's, U. S. Pub. Health Serv.*, Wash., March 1921, XXXVI, No. 9, 434-437.

The field unit of the U. S. Public Health Service has examined the first molar in 6,388 white individuals ranging from 6-17 years of age, and about equally divided between the two sexes. Special attention was paid to caries of the teeth, which was found in 4.8 per cent of all the first molars in the six-year old children—that is within a year or at most a year and a half after eruption. The percentage of children having one or more carious first molars at this age was 14.3 per cent; the boys showing a slightly better condition (12.5%) than the girls (16.1%). This advantage of the males did not appear at some subsequent ages. The largest percentage of carious first molars among boys was observed at the age of ten years; among girls at the age of nine years. At the age of eleven, 54.5 per cent of the children examined showed one or more of these teeth already missing or affected by caries, not counting cases that have received professional aid. One thousand cavities in children from nine to twelve years of age were plotted as to location, with the following results: Occlusal, 877; mesial, 110; distal, 8; buccal, 3; lingual cavities, 2. The very large proportion of cases of occlusal caries points to faulty development of the enamel in some part of the masticatory surface.

INVERTED TEETH. By Murakami (S.)—*J. Perfect Med. Soc. (Jap.)*, 1918, XXIII, No. 4, 9-17.

A report of two cases of inverted canine teeth, associated with infection of the antrum.



## VARIATION—SOFT PARTS

BEITRÄGE ZUR FRAFE DER CUTIS VERTICIS GYRATA UND ZUM KOREANISCH—SPEZIFISCHEN KOPFBANDE "MANG KON" ALS IHRER ENTSTEHUNGURSACHE. By Watanabe (S.)—*Mitteil. mediz. Fachsch. zu Keijo*, 1918, II, 15–28.

The author's observations lead to the following conclusions: "The condition hitherto known as Cutis verticis gyrata does not appear to be caused in a like manner in all cases. Two forms may be distinguished, the idiopathic and the secondary. It can be brought about by prolonged mechanical action such as the constriction caused by wearing the head band ("Mang Kon") characteristically used by male Koreans as part of their national costume. The condition manifests itself in the presence of longitudinally arranged and for the most part parallel furrows in the occipital region of the scalp. From an anthropological point of view the condition might be designated "Korean Head-band folds," though it may also occur among the Chinese.

BEITRÄGE ZUR DAKTYLOSKOPIE DER KOREANER. By Kubo (T.)—*Mitteil. mediz. Fachsch. zu Keijo*, 1918, II, 114–220.

A short historical review is given of the uses to which finger prints have been put in various countries, more especially in China and Japan, followed by a statement of the classification of characters used in general, and of the author's classification. The bulk of the paper is taken up with a detailed study of the conditions obtaining among Japanese, Koreans and Europeans, in the arrangement of the three chief line characters, namely the arch, the loop and the W-formation. This communication is a continuation of the author's earlier work on the physical anthropology of the Koreans.

LE DESSIN PAPILLAIRE DIGITAL DANS L'ART PRÉHISTORIQUE. By Stockis (Eug.)—*Rev. Anthr.*, 1920, XXX, No. 11–12, xlv–lii.

Author calls attention to the utilization by the dolmen builders of Bretagne of the papillary patterns of their fingers for designs which they carved on stone slabs. These patterns, while in general similar to those of man of the same regions today, show nevertheless some interesting features.

DAS STIMMORGAN DER PRIMATEN. By Némai (J.)—*Anatom. Hefte*, 1920, LIX, 1. Abt., 257–292.

This study shows the generally high development of the larynx in primates. The laryngeal cartilages in monkeys and apes resemble closely these structures in man, but the vocal lips are quite different. The arytenoid cartilages are slender and delicate when compared with those of lemurs and all other mammals.

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A NOTE ON THE RELATION BETWEEN THE WEIGHT OF THE THYROID AND THE WEIGHT OF THE THYMUS IN MAN. By Scammon (R. E.)—*Anat. Rec.*, XXI, No. 1.

The variability in weight of the thymus and the thyroid in presumably normal young adults (as determined from the data of Dustin and Zunz) is very great. The weights of these organs show a slight negative correlation in early maturity. The weights of the thymus and thyroid in the newborn also vary greatly, but they show a slight positive correlation. The conclusions of Dustin and Zunz as to the value of this data as evidence of a functional correlation between the thymus and thyroid are not substantiated.

FURTHER OBSERVATIONS ON THE GASTRO-INTESTINAL TRACT OF THE HINDUS. By Pan (N.)—*J. Anat.*, July, 1920, LIV, Part 4, 324-331.

Observations on 84 subjects. "The average total length of the intestinal canal in Hindus is thus calculated to be 26 ft. and is thus much less than the length noted in persons who take a greater proportion of meat and a smaller proportion of carbohydrate food.

"In persons living on bulky carbohydrate food the intestinal canal is expected to be longer in order to accommodate a bulky refuse. Thus in herbivorous animals the intestinal canal is comparatively longer, whereas in carnivorous animals the intestinal canal is shorter but more muscular.

"The experiments of Babak (cited from Madinavetia, *Physiologia Palaeologica de la Digestion*, Madrid, 1910) have shown that in animals of the same species even, taken quite young and growing, if some are fed exclusively upon vegetable food and others mostly on meat a similar adaptation in length occurs, viz. a greater length in the animals fed on vegetable diet.

"In Japanese and Chinese, who also live mostly on a bulky carbohydrate food, a marked increase in the length of the intestinal canal has been noted. But here taking the average of 149 cases, there is rather a decrease in the length of the intestinal canal observed. Thus it occurred to me that greater accommodation for the excreta may be provided by an increase in the breadth rather than an increase in length. So I noted the breadth as well in the second series of 84 subjects. The average greatest breadth of the small intestine in these cases has been found to be  $1\frac{1}{2}$  inches and that of the large intestine  $2\frac{1}{2}$  inches. So it is probable that the intestinal contents are comparatively rapidly ejected as they excite peristalsis mechanically by their bulk and nature and as such these vegetarians as a rule seldom suffer from constipation and the intestines rarely remain loaded.

"In carnivorous animals a shorter vermiform process is found than in herbivorous animals. Consistently with this a larger vermiform process is expected to be present in vegetarians. But here it is shorter and it may be that the nature of the diet plays no part in determining the length of the vermiform process."

RACIAL AND SEXUAL DIFFERENCES IN THE APPENDIX VERMIFORMIS. By Bayon (Henry)—*Anat. Rec.*, Sept. 1920, XIX, 241-249.

"The musculature of the white appendix is not weaker; indeed it seemed slightly stronger than that of the negro. The female appendix is richer in fat than the male. The white appendix is richer in crypts. The white appendix is rich in lymphocytes and poor in vascularity and the negro appendix rich in vascularity and poor in lymphocytes. The white appendix is shorter and wider than the negro appendix. The male appendix is longer and wider than the female appendix."

#### VARIATION—BRAIN

NORMS FOR SOME STRUCTURAL CHANGES IN THE HUMAN CEREBELLUM FROM BIRTH TO OLD AGE. By Ellis (Robert S.)—*J. Comp. Neur.*, August, 1920, XXXII, 1-33.

In the new-born the human cerebellum is relatively small compared to the cerebrum, but it grows fast and at the age of about 15 months it has acquired approximately the same relative weight which it shows during the rest of life. The relative weight of the cerebellum does not vary to any significant degree with the stature, sex, race or intelligence of the individual. The commencement of senility is marked by the gradual loss of the cells of Purkinje with a consequent loss of the mielin fibres. This loss is related to the gradual loss of muscular strength and coördination which are so characteristic of old age.

FISSURAL PATTERN IN FOUR ASIATIC BRAINS. By Cole (Sydney J.)—*J. Anat.*, July, 1920, LIV, 311-323.

The description applies to the brains of a Chinese, a Japanese, a Goanese and an Arab. Mere data; no comparative or critical consideration.

DER GEHIRNREICHTUM DER AUSTRALIER UND ANDERER HOMINIDEN, BEURTEILT NACH IHREM SKELET. By Hauger (O.)—*Anatom. Hefte*, 1921, LIX, 1. Abt., 577-618.

A detailed mathematical attempt to correlate the skull capacity to the total volume of the long bones of the extremities, based on a material of 20 Australians, 11 Europeans, and a few scattered representatives of other races.

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#### VARIATION—RACIAL

NATIONALITY AND RACE FROM AN ANTHROPOLOGIST'S POINT OF VIEW. *The 21st Robert Boyle Lecture*, del. bef. the Oxford Univ. Jun. Sc. Club, by Keith (Arthur), Oxford (Eng.), Nov. 1919. 8°, 39 pp.

The author, in his usual interesting and not pedantic way, discusses briefly the following phases of the problem: Nationality and Race in Boyle's Time; Race and Nationality in Recent Years; Inherited In-



instincts and Modern Ideals out of Harmony; Racial and National Problems in the United States of America; Problems of Canada; Racial Problems of Spanish America; Struggle between Race and Sex Impulses; Race Problems in Australia and New Zealand; National and Racial Problems in South Africa; Some of the National and Racial Problems of Europe; Are the Jews a Separate Race?; National Movements are of Two Kinds; British National Problems; Are Celts and Saxons of Different Racial Stock?; All British Nationalities are of the North Sea Stock; Two Kinds of Colonization—Spontaneous and Forced; The Saxon Settlement of Britain; The Plantation and Colonization of Ireland; Nature of Tribal Instinct; Tribal Isolation Provides the Conditions Necessary for Race-Breeding; Conditions of Tribal Disintegration; Origin of Race Feeling; Transformation of a Tribal into a National Spirit; Tribal Instincts now Manifested in Everyday Life; Knowledge of Tribal and Racial Spirit is Essential for Statesmen; and The Problem of Ireland.

DE LA POSSIBILITÉ DE DÉTERMINER LES RACES HUMAINES PAR LES RÉACTIONS BIOLOGIQUES SPÉCIFIQUES. By Welsch (H.)—*Rev. Anthr.*, 1920, XXX, No. 11-12, xxxiii-xl.

Discusses Bruck's as yet unconfirmed statement that it is possible to distinguish the white, mongolic and other races by biologic reactions used for the determination of species among animals. On the basis of sound physiologic and biologic considerations concludes that while perfected technique will enable with a growing certainty to determine different species, it appears to remain important for the determination of races.

UN ESSAI DE RECONSTITUTION PLASTIQUE DES RACES HUMAINES PRIMITIVES. By Rutot (A.)—4°, Bruxelles, 1919, 172 pp.

The work brings excellent illustrations of the notable Rutot-Mascreé series of reconstructions of ancient man. In the text, essentially archaeological, Professor Rutot once more presents his well-known views as to man's antiquity and its various phases.

THE COLOR INDEX OF THE BRITISH ISLES. By Parsons (F. G.)—*J. Anthr. Inst.*, 1920, L, 159-182.

The paper reports and utilizes extensive observations on the color of hair and eyes in different parts of England. The observations were not as detailed and precise as might be desirable, but have the advantage of numbers and for general purposes seem sufficient. The results show that the townspeople are darker than the surrounding country folk; that the females are in general darker than the males; and that there are considerable regional differences in pigmentation. For the easier expression of the degree of pigmentation the author uses an index "obtained by adding the percentage of dark brown and black hair to

that of the dark eyes and dividing the result by 2." The subdivisions of color used are, for the hair—red, fair, brown, dark brown and black; for the eyes—light and dark. As to red hair the records show "that England has the smallest proportion of red hair, and Scotland the largest, while Wales is higher than Ireland in redness."

ANTHROPOLOGICAL OBSERVATIONS ON GERMAN PRISONERS OF WAR. By Parsons (F. G.)—*J. Anthropol. Inst.*, 1919, XLIX, 20-35.

Measurements and observations on approximately 1000 Germans and a series of Englishmen, extending to the cephalic index, the facial index, the hair and eye color, and the stature. The results show, in brief, that the average cephalic index of the Germans from all provinces ranges from subbrachy- to brachycephalic, while that of the English is mesocephalic. In the author's words, "The more one thinks of it the more one is convinced that since the sixth century the broad-headed Alpine race has been slowly and steadily supplanting the long-headed Nordic type, not only in Prussia but in every part of Germany, and the prisoners at our disposal give us no reason for thinking that there is any part of modern Germany in which the Alpine or Slav characteristics have not dominated the Teutonic or Nordic." The German face too, is shorter than the English. "This evidence of the face supports my contention that the original inhabitants of north-western Germany have been supplanted by men of another race, with short, broad faces, as well as round heads. Our own Anglo-Saxon skulls, with due allowance for the soft parts, show an average face index of well over 90, and it is possible that, as the skulls in the Bremen row-graves had the same characteristics, they resembled them in the face also." Head height is slightly superior in the Germans as compared with the English and the same is true of estimated head capacity. The average pigmentation is slightly less than in English, but red hair is twice as common in the latter. The stature of the Germans averaged 5 ft. 6.1 in. to 5 ft. 8.1 in. according to provinces. The English average "is probably 5 ft. 8 in. or less." The tall provinces in Germany are in the north and west while the shorter men inhabit the south and east.

UEBER DIE MENSCHLICHEN SKELETTRESTE AUS DEM PHAHLBAU AM ALPENQUAI IN ZÜRICH. By Schlaginhaufen (O.)—*Vierteljahrsschr. d. Naturforsch. Ges. Zürich*, Jahrg. 62, 1917, 488-500

A detailed description of two adult and one juvenile well preserved skulls and of a number of long bones of the lower extremity, of the Swiss lake dwellers. These were discovered recently in Zurich, the particular station belonging to the late Bronze epoch. The material is too inadequate to allow any racial diagnostic conclusions. One of the adult skulls shows complete metopism.

A. H. SCHULTZ.

LES WENDES. By Vaux Phalipan (Mme. de)—*Rev. Anthropol.*, 1920, XXX, 283-288.

First chapters of, a work on the early extension of Slavs in what is now Germany. It merely accentuates the need of a thorough impartial study of the whole subject.

LES PEUPLES DES BALKANS.—4°, Geneve & Paris, 1920, 634 pp. A commentary by G. Hervé, *Rev. Anthropol.*, 1920, XXX, 293-9.

Dr. Pittard's painstaking study, abstracts of parts of which have been published before, extends to 3,500 individuals comprising all the principal groups of Balkan peoples. The author seems to have recognized in these populations three distinct fundamental types:

1. People of tall stature, brachycephalic, dark;
2. People of tall stature, dolichocephalic, light;
3. People of somewhat shorter but still above the average stature, brachycephalic or sub-brachycephalic, and dark.

The first of these types is found especially in the western parts of the peninsula: it is the Dinaric or Illyrian type; the second type is well represented among the Serbians as well as the Bulgarians; the third type—seemingly less well justified—is especially common among the Rumanians.

THE ANTHROPOLOGY OF CYPRUS. By Buxton (L. H. Dudley).—*J. Anthr. Inst.*, 1920, L, 183-235

"There is evidence of two classes of head length in Cyprus, and contrary to expectation this appears to be inversely correlated with stature." A considerable instability of the nasal breadth may possibly be accounted for by the admixture of negroid elements. The population, while showing a mixed composition, has apparently not changed much since the Bronze age.

It is regrettable that instead of or besides the mathematical discussion which takes up a disproportionate part of the paper, there could not have been added a comprehensive summary of the results of the study.

THE FINNIC QUESTION AND SOME BALTIC PROBLEMS. By Peake (Harold)—*J. Anthr. Inst.*, 1919, XLIX, 181-203.

A stimulating, well based discussion of the subject. Author shows the untenability of the opinion that would attribute the real Finn to the Nordic race. They are apparently old (neolithic) immigrants of Asiatic derivation. As to more detailed generalizations there are the blocking difficulties of insufficiency of skeletal material from many regions.

HISTORY AND ETHNOLOGY IN CENTRAL ASIA. By Czaplicka (M. A.)—*Man*, Feb., 1921, XXI, 19-24.

The paper points to the erroneous applications of the terms Tatar and Mongolian in anthropology of the Asiatic races.



BEITRAEGE ZUR PHYSISCHEN ANTHROPOLOGIE DER KOREANER. By Kubo (Takeshi)—*Mitteil. Mediz. Fachsch. z. Keijo*, 1917, 212 pp.

A painstaking study of the Koreans, with comparative data on the Japanese. The results show that there are numerous more or less important differences between the two peoples. The cephalic index of the Koreans, averaging 83.2 in the men and 83.3 in the women, is higher than that of Japanese (approx. 81.0 and 81.5 resp.). The Korean head and especially skull is also higher than that of the Japanese; the Korean face and nose are somewhat broader. The pigmentation of hair, iris and beard is somewhat higher in the Japanese. The author devotes considerable attention to the detailed description and count of the hair of the brows, eyelids, nose, ears, and face.

ON THE CEPHALIC INDEX OF THE JAPANESE MEN AND ITS LOCAL DIFFERENCES. By Matsumura (Akira)—*Orient. J. Sc.*, Tokyo, Nov. 1918, XXXV, No. 446, 643-655 (in Jap.).

Distribution in 4980 men:

Up to 69.9	70-74.99	75-79.99	80-84.99	85-89.99	90-94.99	95-95.99
%3=0.06	239=4.80	1877=37.7	2294=46.1	520=10.44	42=0.84	5=0.1

ON THE CEPHALIC INDEX OF THE JAPANESE WOMEN AND ITS LOCAL DIFFERENCES. By Matsumura (Akira)—*Orient. J. Sc.*, Tokyo, Feb. 1919, XXXVI, No. 449, 105-116 (in Jap.).

Observations on 2000 subjects:

68-69.99	70-74.99	75-79.98	80-84.99	85-89.99	90-94.99	95-95.99
1 0.05	37 1.85	555 27.75	1020 51.0	341 17.05	45 2.25	1 0.05

ON THE CEPHALIC INDEX OF THE LUCHU ISLANDERS. By Matsumura (Akira)—*Orient. J. Sc.*, Tokyo, Oct. 1919, XXXVI, No. 457, 568-577 (in Jap.).

Observations on 140 men and 68 women:

72-74.99	75-79.99	80-84.99	85-89.99	90-92.99
♂1.44 ♀2.9	40.7 35.3	49.3 42.6	7.85 17.6	0.7 1.5

A NEW THEORY OF POLYNESIAN ORIGINS. By Dixon (Roland B.)—*Proc. Am. Phil. Soc.*, 1920, LIX, No. 4, 261-267.

Author's study of available data "seems to show that the racial history of the Polynesian area is even more complex than it has hitherto been supposed to be. The underlying stratum here, as well as further westward, appears to be indistinguishable from the Negrito, although the problem of how it reached this remote region is not yet wholly clear. This stratum was followed by a wave of negroid peoples whose most

numerous modern representatives in this portion of the world form the bulk of the population of Melanesia and Australia. As a result of this influx, the earlier Negrito type was largely absorbed, and survives today as such, only in remote marginal areas into which it was driven by the negroid immigrants. Following the negroid came the Malayoid or Mongoloid wave, which, spreading over the area, absorbed and apparently quite submerged the preceding types and blends in western Polynesia, and flooded in force into the central, southern and northern portions, so that the Austro-Melanesian or negroid type and its predecessor were left in any degree intact, only in the marginal areas. These successive waves must not, however, be thought of as rapid conquests, but rather, for the most part, as slow drifts requiring generations or centuries for their completion, with periods of halting, and as following moreover somewhat different paths."

A PROPOSITO DELLA LEPTORRHINIA DEI MORIORI E DELLA LORO DIFORMAZIONE CRANICA. By Giuffrida-Ruggeri (V.)—*Rend. R. Acad. Sc. fis. e nat. di Napoli*, Ser. 3°, XXVII, 1921, 1-3.

In this article two sets of changes which are attributed to adaptation to a cold climate are considered. First the occurrence of leptorrhiny in mesorrhine races who have a circumpolar habitat, the narrowing of the nose ensuring that the air shall be more perfectly warmed by closer contact with the turbinated bones: the Eskimo in the arctic hemisphere and the Moriori in the antarctic are the most typical examples of this change. To the Moriori must be added the Maoris and the Fuegini. In the second place the author discusses the modifications due to increased development of the masticatory muscles; the scaphocephaly of the Eskimo and the *Torus sagittalis* of the Moriori. He believes that as a great development of the maxillary bone takes place this also produces the lengthening of the nasal skeleton, which would explain that the leptorrhiny of the Moriori is produced more by the lengthening of the nasal bones than by the diminished width of the nasal opening. (Compare Hrdlička's "Contributions to the Anthropology of Central and Smith Sound Eskimo," *Anthrop. Papers, Amer. Mus. Nat. Hist.*, 1910, V, Part II.)

The author considers also the presence of certain characteristics of inferiority in the Moriori, some of which however he believes to have been wrongly interpreted by Mrs. Thomson, who did not recognize that the skulls which she believed to be typically male and which had very receding foreheads, were really artificially deformed.

CONTRIBUTIONS TO THE ETHNOGRAPHY OF MICRONESIA. By Matsu-mura (Akira)—*J. Coll. of Sc.*, Univ. of Tokyo, 1918, XL, Art. 8, 174 pp.

The fact that the natives of the West Caroline Islands stand on a different level of civilization from those of the East Caroline Islands is undeniable. At the same time, it may be noticed that their manners

and customs are also different. As regards the physical characteristics, the natives of the East Carolines are dolichocephalic, with a narrow face and of a medium stature; whereas the islanders of the Western group are mesocephalic or rarely brachycephalic, with a broad face and of a more or less higher stature when compared with the former.

The racial characteristics are always found intermingled, none of them being peculiar to one race. In other words, they partake of the characteristics of the races inhabiting Micronesia and its neighborhood. Their civilization may be called Malay in origin or application, in that the natives of Micronesia know the art of weaving and wear cloth petticoats or waist-cloths; it is Papuan, in that the women wear coarse petticoats; it is Malay or Melanesian, in that the islanders of the West Carolines make pottery and chew betel-nut; and their manner of preparing food and the drinking of *kava* are shared by the Polynesians and some tribes inhabiting Melanesia. It will thus be seen that the islanders of the East and West Carolines have many things in common with other tribes in Polynesia, Melanesia and the Malay Archipelago.

"The fact that they partake of the ethnical characteristics of those races seems to be almost a demonstration that they are tribes of mixed blood. Consequently, we would not be justified in treating the Micronesians as forming one and the same stock with the Polynesians, this negative conclusion being confirmed by the study of their ethnographical as well as their physical characteristics. But we cannot believe that racial intermixture has taken place in the East and West Caroline Islands to the same degree, for, from what we saw, they are different both ethnographically and somatologically. The West Carolines are situated nearer to the Philippine Islands and New Guinea than the East Carolines, and the natives of the former seem to possess more racial characteristics in common with the natives of the Philippines and New Guinea than the East Caroline Islanders. This is true not only ethnographically but somatologically as well, inasmuch as not a few natives in Yap and Palau are frizzy haired and brachycephalic. Ethnographically, Polynesian or Melanesian elements are in evidence in the East Caroline group, but not so prominently as is the case in the Western group mentioned above. Of the physical characteristics of the East Caroline Islanders the same observation may be made. In short, the natives of Micronesia are an intermixture of various neighboring tribes, and should now be regarded, in the writer's opinion, as constituting a distinct race, the Micronesian, rather than a group belonging to another race."

EARLY FIJIANS. By Hocart (A. M.)—*J. Anthropol. Inst.*, 1919, XLIX, 42-51.

"Perhaps the most crying need of anthropology is a certain and reliable method of placing events in time," and the "purpose of this paper is not to discourse at large upon principles, but to show their practical application to the historical problems of the Pacific Ocean. . . .



At the foot of the great dividing range the people are short, dark, fuzzy-haired, with a deep dent at the base of the nose. As we move eastward they become, as a rule, taller, lighter in color, the dent of the nose is less marked; wavy, even straight, hair appears in the east. The less negroid appearance of the Easterners is usually ascribed to the Tongan invasion, which began nearly a century and a half ago; but that will account at most for the physique of the Lauans, but not for the rest of the coastal Fijians. Since the migrations took place from west to east, from a region of more to one of less negroid types, we must conclude that previously the eastern Fijians were even more like their polynesian neighbors than they are now. That is simple arithmetic: subtract the hill type from the Eastern type; the remainder must be something like the Samoan or Tongan." The illustrations show on the one hand the Negrito and on the other the Polynesian or allied strain, which contains blood of Indo-Europeans.

REISEN UND FORSCHUNGEN IN DER MELANISCHEN SUDSEE. By Schalighaufen (Otto)—*Sitzungsb. d. Anthropol. Ges.*, Vienna, 1920, Jahrg. 1919-20; Repr. 6 pp.

A general preliminary report on author's anthropological investigations in Melanesia, including New Guinea. No specific deductions.

AFFINITÀ ANTROPOLOGICHE FRA ETIOPICI E ARABI MERIDIONALI. By Giuffrida-Ruggeri (V.)—*Ann. R. Inst. Orient. di Napoli*, 1919-20; Repr. 4°, 7 pp.

The author recognizes two forms of affinity between the southern Arabs and the Ethiopians; one, ancient, based on the original identity of the race from which both peoples were derived; and second, more recent, due to the coming of Ethiopians to Arabia and of Arabs into Ethiopia.

SOME OBSERVATIONS ON THE PHYSICAL CHARACTERS OF THE MENDE NATION. By Migeod (F. W. H.)—*J. Anthropol. Inst.*, 1919, XLIX, 265-270.

The Mende blacks inhabit the eastern part of the Sierra Leone Protectorate. They are a mixed people. The measurements of stature indicate the intermixture of a very short race with a tall one.

#### DEMOGRAPHY

THE EFFECT OF THE WAR ON THE CHIEF FACTORS OF POPULATION CHANGE. By Pearl (Raymond)—*Science*, June, 1920, No. 1327; Repr. 4 pp.

Author considers changes of population during the war period in France, Germany and England. "The essential and outstanding fact is that the net biological outcome of the complex interplay of forces resulting from war was almost identically the same in France and

Germany. Another interesting point is that while France started in 1913 with a death-birth ratio 40 per cent higher than that of the German states—she having at that time an approximate equality of births and deaths—nevertheless the biological changes induced by the war, as expressed in this ratio, were the same for the one as for the others. We are evidently dealing here with deep-seated and fundamental phenomena of racial biology.”

A FURTHER NOTE ON WAR AND POPULATION. By Pearl (Raymond)—*Science*, Feb. 1921, LIII, No. 1362, 120–121.

“These examples, which include the effects of the most destructive war known to modern man, and the most devastating epidemic since the Middle Ages, furnish a substantial demonstration of the fact that population growth is a highly self-regulated biological phenomenon. Those persons who see in war and pestilence any absolute solution of the world problem of population, as postulated by Malthus, are optimists indeed. As a matter of fact, all history definitely tells us, and recent history fairly shouts in its emphasis, that such events make the merest ephemeral flicker in the steady onward march of population growth.”

ON THE RATE OF GROWTH OF THE POPULATION OF THE UNITED STATES SINCE 1790 AND ITS MATHEMATICAL REPRESENTATION. By Pearl (Raymond) and Reed (Lowell J).—*Proc. Nat. Acad. Sc.*, VI, No. 6, June, 1920; Repr., 8°, 14 pp.

On the basis of essentially mathematical considerations, the authors advance the views that for the United States the period of most rapid population growth was passed somewhere in the last decade; and that “the maximum population which continental United States, as now areally limited, will ever have, will be roughly twice the present population.”

THE THEORY OF LARGE POPULATION-AGGREGATES. By Knibbs (G. H.).—*Metron*, 1920, I, No. 1, 113–125.

“Any large population-group must necessarily tend at each moment to increase according to an exponential law with a positive index and the rate of which initially may accelerate. In all cases this rate must ultimately decrease, until it becomes zero.” . . . “The present population of the world, and its recent rate of increase, is such that it cannot be maintained even for a few centuries, since it may easily be shown that no possible accession of food supplies could meet the requirement.” . . . “Even a very moderate rate of growth, cannot indefinitely postpone trouble, and a people can save itself in this respect only in so far as they can their efficiency to the highest possible limit, and also restrict themselves in regard to all unnecessary luxury. What ever advances are made in science, and its applications in industry, and

in food supply, they cannot of themselves postpone the ultimate resistance to further development, which must inevitably increase and increase until relieved by catastrophe or avoided by discipline."

ON A SINGLE NUMERICAL INDEX OF THE AGE DISTRIBUTION OF A POPULATION. By Pearl (Raymond)—*Proc. Nat. Acad. Sc.*, July, 1920, VI, No. 7; Repr. 6 pp.

Author proposes a new mathematical method for the determination of the age distribution of a population. "In general it is believed that the function of an age distribution of a population here proposed will give, in a single numerical expression, a substantially accurate indication of the essential nature of that age distribution, and will facilitate the differentiation and classification of populations in respect of this characteristic for statistical studies, particularly by the method of multiple correlation."

ON THE MEAN AGE AT DEATH OF CENTENARIANS. By Pearl (Raymond)—*Proc. Nat. Acad. Sc.*, March, 1919, V; Repr. 4 pp.

"As was to be expected the mean ages at death are sensibly lower, and the standard deviations smaller, when the graduated data of the life tables are used instead of the raw statistics. Inasmuch as the life table values given in table 4 are certainly nearer the true values than those of table 2, they may well be adopted as the basis of centering deaths over 100 in biostatistical computations. Accordingly in this laboratory the deaths of whites, both male and female, occurring at 100 years and over will be assumed to centre at 101.7 years and those of negroes at 102.0. The latter value is probably still too high, but unless one repudiates the statistical data entirely, which would amount to throwing away the child with the bath, there is no warrant for arbitrarily taking a lower value."

THE RELATIVE NUMBERS OF TWINS AND TRIPLETS. By Zeleznik (Charles)—*Science*, March 18, 1921, LIII, No. 1368, 262-263.

"If  $1/n$  is the proportion of twin births to all births in a large population during any period, then the proportion of triplet births during the same period is very near to  $1/n^2$ ." The biological significance of this is as yet uncertain.

THE MORTALITY OF RACE STOCKS IN PENNSYLVANIA AND NEW YORK. By Dublin (Louis I.) and Baker (Gladden W.)—*Am. Statis. Assoc. Quart.*, March, 1920; Repr., 32 pp.

"Of the three main groups of the white population in Pennsylvania and in New York, (a) native born of native parents, (b) native born of foreign or mixed parentage, and (c) foreign born, the first has the lowest mortality. This is true for both sexes and for virtually every age period, but is most marked at the adult ages. The foreign born,



and the native born of foreign or mixed parentage, agree much more closely with each other than with the native stock. An interesting exception presents itself, however, at ages 25-44, at which period the foreign born have a great advantage over the native born of foreign or mixed parentage. The reason for this is the predominance of the Irish, German and British stocks among the first generation Americans at this age period. After age 45, these two groups of the foreign stock are of the same racial extraction, and their death rates are in very close agreement. The death rates of the component groups among the foreign born vary considerably. The Austro-Hungarians, Russians and Italians present altogether favorable conditions, while the British, Germans and Irish show death rates very greatly in excess. This is especially true of the Irish, whose mortality is about double that of the native stock. The rates for the Germans, British and Irish are much higher in America than in their own countries. Pulmonary tuberculosis, pneumonia and the degenerative diseases including heart disease, Bright's disease and cancer are largely responsible for this unfavorable mortality. The findings of the previous study for New York State are confirmed. The unfavorable conditions of life and work among foreign races to which attention was directed in the study for New York are found to prevail in Pennsylvania as well. The facts emphasize the necessity for special public health work for the people of foreign origin. The much more favorable economic conditions under which they live in the United States than in their own countries should result in lower death rates. But in several instances, we found that this does not prevail; the facts indicate, on the whole, deterioration rather than improvement. Is it possible that our immigrants are not representative of the best in their native countries? It has often been supposed that the immigrants comprised the most vigorous among their own people; the results however, do not confirm this impression, but suggest many questions for further inquiry. It is very important that a study similar to this one be carried out as soon as the results of the 1920 census are available, to determine whether any differences of importance have appeared in the interval of ten years."

ABNORMAL CLASSES—COMPARATIVE HUMAN PATHOLOGY AND  
TERATOLOGY

ANNUAL REPORT OF THE SURGEON GENERAL OF THE PUBLIC HEALTH  
SERVICE OF THE UNITED STATES. 8°, Wash., 1920, 391 pp.

This comprehensive report, while not to be reviewed in detail in this place, should nevertheless be called to the attention of anthropologists. It contains records of extensive activities and observations which cannot but be of interest to the eugenicist and to the student of comparative human pathology.

INFANT MORTALITY (in Saginaw, Mich.). By Allen (Nila F.)—*U. S. Children's Bureau Publ. No. 52*, 8°, Wash., 1919, 91 pp.

A report on the "results of a field study in Saginaw, Mich., based on births of one year." It deals with: Infant mortality rate; cause of death; age at death; stillbirths; sex; feeding; nationality, literacy, age of mother; order of birth; economic factors; maternal histories; housing, ward conditions, description of the city; history; climate; population; political characteristics; industries; physical characteristics; sanitation; sewerage and surface drainage; water supply; milk supply; garbage and refuse disposal; civic and social agencies. In the conclusion of her meritorious piece of work the author accentuates particularly the need of an adequate prenatal care of the mother.

ILLEGITIMACY AS A CHILD WELFARE PROBLEM. By Lundberg (Emma O.) and Lenroot (Katharine F.)—*U. S. Children's Bureau Publ. No. 66*, 8°, Wash., 1920, 105 pp.

The well written report deals with the extent of the problem; infant mortality; the child's status and right to support; and protection and guardianship; to which is added an extensive "Bibliographical Material on Illegitimacy as a Child-Welfare Problem," which will be welcomed by workers in this line.

MORTALITY STATISTICS OF CANCER AMONG WAGE EARNERS: WITH OBSERVATIONS ON THE COMPARATIVE INCIDENCE OF THE DISEASE IN THE GENERAL POPULATION.—*J. of Cancer Research*, July 1919, IV, No. 3, Rept. 27 pp.

"During the six year period of this investigation, 37,666 cancer deaths were recorded at a rate of 70.0 per 100,000 persons exposed. Cancer was the sixth cause in order of numerical importance in this study. These deaths constituted 5.9 per cent of all the deaths in the experience." As to age, color and sex "White persons show higher cancer death rates than colored persons, although the white female rate is only slightly higher than that for colored females. Various differences between the cancer death rates of the color and sex classes occur for this disease as it affects various organs or parts. White males, for instance, show uniformly higher cancer death rates for each of the organs or parts, when compared with the rates for colored males. White females show significantly lower cancer death rates for this disease, only as it affects the female genital organs and the breast. Cancer of the uterus and of the other genital organs shows a rate of 25.3 per one hundred thousand white females exposed and a rate of 37.9 for colored females. Cancer of the breast, in this present mortality experience, was recorded at a rate of 11.7 per one hundred thousand white females, and at a rate of 14.7 per one hundred thousand colored females. For the other chief organs or parts cancer mortality of white females is greater than among colored females. . . . A fairly significant rate is registered for the ages one to four years in the total experience. The cancer rate declines thereafter to its minimum at ten to fourteen years of age and then rises, at first gradually, but afterward in heavy increments

up to the latest age period in this series. The same general characteristics of the age course of cancer mortality are observed for white males as for white females, with the exception that the upward slope of the curve for white females is very much sharper for the ages beyond 25 years. The cancer death rates for colored persons under 25 years of age are, for the most part, very low, and fluctuate somewhat irregularly. Beginning with the age period 25 to 34 years, however, there is a constantly increasing rate, up to the highest age period recorded in this series. . . . White males show emphatically higher cancer death rates at every age period than were recorded for colored males. Comparisons between the cancer death rates of white and colored females are practicable beginning with the age period 25 to 34 years. Between 25 and 44 years, the cancer death rate of white females was decidedly lower than the rate for colored females. Between 45 and 54 years, the rates were practically the same. Beginning with the age period 55 to 64 years, and continuing to the highest age period of the table, we observe that the cancer death rate of white females was much higher than the rate for colored females. These differences in the total cancer death rates of white and colored females are to be accounted for, as will be shown later, by the higher mortality from cancer of the generative organs among colored females."

As to sex, "there are no important differences in the cancer mortality of the two sexes among white lives under 25 years of age. Beginning with the age period 25 to 34 years, however, the cancer death rates of white females exceed those of white males substantially up to and including the age period 55 to 64 years. Thus at the age period 35 to 44 years the rate for white males was only 38.6 per cent of that for white females. After age 65, the disproportion between the rates for the two sexes among white lives is not so great.

"The excess of the cancer death rate of colored females over the rate for colored males is much greater than was observed, age period by age period, for white lives. Thus between 25 and 45, the rate for colored males was only about one-fourth as great as for colored females.

"The current medical opinion that there is a strong association between low economic status and a low cancer death rate is in all probability unfounded. The cancer mortality rate at the ages where the cancer rate is significant decreases as we go up in the economic scale. This is true for both sexes and by age period where sufficient data are available. This conclusion is not conditioned by the effect of varying amounts of medical selection in the three groups considered."

UNUSUAL NUMBER OF SUICIDES AND HOMICIDES DURING JANUARY (1921).—*Statist. Bull. Metrop. Life Ins. Co.*, N. Y., Feb. 1921, II, No. 2, 3-4.

"Has the less favorable industrial situation of the latter part of 1920 and the early part of this year resulted in increased numbers of suicides and homicides? There have been more of each recently in the wage-



earning group of the population. The record in the industrial Department of the Metropolitan Life Insurance Company for January shows a sharp increase in the death rate for these two causes. Under normal conditions we do not expect maximum suicide mortality at this time of the year. A larger number of suicides occur in May than in any other month. June is another month of high suicide mortality. January suicide rates are ordinarily low. Yet in the 1921 records of the Industrial Department of the Metropolitan, a suicide rate of 7.7 per 100,000 industrial policy-holders was registered for January. This is higher than was shown for any month of 1920.

"As for homicide, the January, 1921, rate was 7.2 per 100,000 and this was higher than that for any month of the year 1920 with the single exception of September. The figure for January, 1920, was 4.3, for November 5.1 and for December it was 6.8.

"The relation of color to suicide and homicide is interesting. Suicide is a very minor cause of death, numerically, among colored persons. The situation is just the reverse with homicide among both colored males and females. The experience of years has shown that without exception the homicide rate for colored persons is many times greater than that for whites."

ARTHRITIS DEFORMANS OF THE KNEE AS A SENILE CHANGE. By Yamagiwa (K.) and R. Yamamoto—*Trans. Med. Soc. Tokyo*, 1919, XXXII, No. 23, 30-60 (in Jap.).

"The material studied consisted of 65 human bodies, between the ages of 4 and 76. Bodies showing changes other than those which might be attributed to age were excluded. The average number of such changes found increased progressively from 3 between 30 and 35 years, to 18 between 76 and 80 years. The changes consisted in a whitish or yellowish discoloration, a loss of normal gloss, or a velvety appearance of the joint surface, defects shallow or deep, erosions, eburnation, or exostosis formation.

These changes the authors regard as simple regressive changes on the one hand and compensatory reparative changes on the other, quite analogous to arteriosclerosis, and suggest for them the term "*Arthropathia deformans senilis*." They regard the atrophic and hypertrophic forms as different stages of the same process, and the usually greater age incidence of the latter as due to the fact that the reparative changes necessarily follow the degenerative changes.

The authors think that "sub-cartilaginous changes in the bone are always associated with detectable, though sometimes slight, changes in the cartilage, described as a "fibrinoid" degeneration, and formation of lacunae. These areas take a bluish-violet color with Weigert's fibrin stain, and under high magnification show a fine reticular network of fibrils. This change occurs very early (37-40 years) in the deep layer of the joint cartilage, in semilunar areas which stain intensively with eosin and undergo softening. These transverse slits enlarge both laterally and longitudinally toward the joint surface, unite with the slits

which form in the superficial portions of the cartilage by its fibrillation, and lead to deep erosions of the cartilage. The cartilage beneath these areas undergoes a transformation into fibrils which are perpendicular to the joint surface, and ossification of this altered cartilage takes place. There is also proliferation of the bone and marrow beneath these areas, resulting in nodular irregularities on the surface of the cartilage. These nodules may be broken off and pressed into the underlying bone by the movements of the joint, and thus give rise to cartilaginous islands in the bone. All the changes in the bone itself are regarded as secondary. Fibrous change of the bone-marrow takes place where the degenerative changes described have occurred in the cartilage. The formation of exostoses along the margins of the joint occurs in the same manner, in that the hyaline cartilage is transformed into fibrous cartilage, bone is deposited in it, and marrow may develop in it as a result of lacunar bone resorption. Eburnation may occur anywhere as a result of rubbing together of exposed bone surfaces."

## SEVERANCE REVIEWS.

MALIGNANT TUMORS IN JAPANESE. A STATISTICAL STUDY. By Suzuki (N.)—*Kyoto J. Med. Sci.*, 1919, XV, No. 6, 51-58 (in Jap.).

"The figures include the cases of malignant tumors occurring in the province of Yamashiro for the years 1905-1914. The mortality from malignant tumors in the city of Kyoto was 3.95 per 100 deaths, and 80 per 100,000 living. The highest mortality was in the village of Kumoghata, 255 per 100,000 living, and in Takayama, 197 per 100,000; the lowest in Kita, 36 per 100,000. In the former the inhabitants eat much meat and drink hot drinks; in the last named district the diet is largely vegetarian.

"The incidence in Japan is not less than that in Europe. An inherited predisposition to carcinoma was frequently observed, the organ involved being frequently the same in parent and child, but in no case did sarcoma occur in both parent and child.

"In Japan the incidence is higher in men than in women. In carcinoma of practically all organs the percentage incidence in men is relatively greater in Japanese than Europeans. Males are more frequently affected than females by carcinoma of the stomach, oesophagus, rectum, intestine, liver, pancreas, tongue, larynx, pharynx, lung and skin. The incidence of carcinoma of the bile passages is about equal in the two sexes, while cancer of the breast and thyroid is commoner in women.

Organ	Frequency in Both Sexes	In Males	In Females
Stomach.....	33%	4%	25%
Oesophagus.....	6-10%	6-21%	2-6%
Intestine.....	6-11%	6-18%	6-17%
Rectum.....			8%
Liver (primary)..	6%		
Bile passages....	3-6%		
Pancreas.....	1-3%		

"The order of frequency in males was: stomach, intestine, oesophagus, liver, tongue, buccal membrane, axilla, penis, skin. In females: uterus, breast, stomach, intestine, maxilla, etc.

"The chief differences not already mentioned are in the greater frequency of primary carcinoma of the liver and of rectal carcinoma in women.

"The age incidence was the same as in Europe. The greatest frequency was in the sixth decade, except for carcinoma of the uterus, which was in the fifth decade. The average was: liver, 41.2; uterus and ovary, 42.7; stomach, 47; maxilla, 55.0; ball bladder and bile passages, 55.1; prostate, 57.0; larynx, 58.9.

"The incidence was greater in shopkeepers and in those leading a sedentary occupation than in those doing heavy muscular work. It was greater in individuals of robust physique than in poorly developed individuals, except in case of carcinoma of the oesophagus, and of the stomach in women.

"The occurrence of carcinoma of the body of the uterus was greater in nulliparae, that of the cervix much greater in multiparae, especially in V parae and VI parae. The average number of births in cancer of the cervix was 0.75 to 2.15 greater than the average. Miscarriage, even repeated, had no relation to cancer incidence. The interval between labor and the onset of carcinoma was often less than two years and usually less than one year.

SEVERANCE REVIEWS.

DAS SKELETT EINES TEILZWITTERS. By Stieve (H.)—*Arch. Entwickl. mech.*, 1920, XLVI, 38-84.

The 41 years old individual, whose skeleton is described in great detail, had hypospadias scrotalis, simulating the appearance of female external genitalia. There were well-developed testes and no ovaries. Sexual maturity in this pseudohermaphrodite was not reached until after the age of 20. The subcutaneous fat was very abundant in the abdominal region, and over the hips. The development and distribution of hair are of the male type. The skeleton shows in some parts typically male, in others typically female characteristics. The skull, especially the mandible, is unusually light, the latter weighing only 50 gms. The skull capacity is 1266 cc. The basion-bregma height (115 mm.), relative to skull length and width, is very small. The percentage relations of the lengths of the different spinal regions are typically female, as is also the shape of the thorax and of the sternum, the size of the latter is relatively extremely small. The pelvis is very large and, in many aspects, of the female type. The pubic angle of only 60°, however, shows more the male condition. The long bones of the extremities are slender and very long in relation to the body height, most marked in case of the radius.

A. H. SCHULTZ.



## THE AMERICAN INDIAN

FIFTIETH ANNUAL REPORT, BOARD OF INDIAN COMMISSIONERS. Washington, June, 1919.

FIFTY-FIRST ANNUAL REPORT, BOARD OF INDIAN COMMISSIONERS. Washington, June, 1920.

The reports are filled with useful data and advice by the individual Commissioners who during the course of the two years have visited various tribes; but they are of little use to science on account of the regrettable omission of all statistical matter relating to the tribes. As there is no other source of similar information, it is most important that a yearly publication of the most important demographic data on the tribes in these reports, be resumed. Shall there be a retrogression instead of progress?

THE IROQUOIS IN CANADA. By Orr (R. B.)—*Thirty-first Ann. Archaeol. Rep.*, Provinc. Mus. Ontario; Toronto, 1919, 9-55.

Article of a general nature, but containing (pp. 51-53) a chapter on "Blood Amalgamation" which is of direct interest to physical anthropology.

"For over three hundred years this process of race amalgamation has been going on, until there are few Iroquois families, indeed, who can justly claim freedom from some trace of white blood. This has resulted in the change of blood quantum from full Iroquois, or rather full Indian, to rather less than the three-quarters Indian and one-quarter white, as a general average. There are numerous half-bloods by intermarriage with whites, and hundreds of "Iroquois" who are of one-quarter, and even less Indian blood. The blood blending is increasing more rapidly now than previously, and in another two generations we may expect that the Grand River and the New York Iroquois will be less than half Indian. It is quite likely that the Iroquois of St. Regis and Caughnawaga are even now less than half-bloods, the predominant blood being French. There are sometimes strange intermarriages. But first let it be said that there are few alliances with the negroes. The Iroquois seem to have never accepted the black man, or perhaps the black man the Iroquois, as a general thing. Some negro blood crept into the Iroquoian stock through the southern Tuscarora, into the Canadian Six Nations, in one or two families, through the American run-away slaves, and into the Sunfish Family of the New York Senecas through a negro who lived at Buffalo creek about 1815. On the whole, however, the Iroquois is less inclined to take the black man to wed than the white man is."

ARE THERE EVIDENCES OF AN IROQUOIAN MIGRATION WEST OF LAKE ERIE? By Houghton (F.)—*Am. Anthropologist*, 1920, XX, No. 3, 293-297.

The question is answered in the affirmative. The discussion, though mainly based on archaeology, is nevertheless of some interest to physical anthropology.

MORTUARY CUSTOMS OF OUR INDIAN TRIBES. By Orr (R. B.)—*Thirty-first Ann. Archaeol. Rep.*, Provinc. Mus. Ontario; Toronto, 1919, 56-76.

The article deals with cremation, mummification, grave burials, surface and mound burials, tree or scaffold burials, consigning the body to water, urn burial and "ossuarial" or secondary burials, mainly among Canadian tribes.

YUMAN TRIBES OF THE LOWER COLORADO. By Kroeber (A. L.)—*Amer. Archaeol. & Ethn.*, 1920, XVI, No. 8; Berkeley, Cal., 8°, 11 pp. Useful notes on tribal and regional identification.

A PROPOS DE LA TACHE MONGOLIQUE AU MEXIQUE. By Gracieux (Ph.)—*Bull. & Mem. Soc. Anthr.*, Paris, 1918, IX, 6-9.

Reports three cases of the "mongolic spot" among newborn Indian infants in the General Hospital, City of Mexico. No statistics or critical discussion.

DISTRIBUCIÓN DEL ÍNDICE CEFÁLICO EN MEXICO. By Pauer (P. Siliceo)—*Ethnos*, 1920, I, 3-5.

A résumé of some older data on cephalic index in Mexico, with addition of observations on the "Teotihuacanos." The majority of the tribes reported upon fall under the subdivisions of subbrachy- and brachycephaly.

BIBLIOGRAFÍA ANTROPOLOGICA OTOMÍ. By Chavez (A. N.)—*Ethnos*, 1920, I, No. 3, 68-73.

LAS EXCAVACIONES DEL PEDREGAL DE SAN ANGEL Y LA CULTURA ARCAICA DEL VALLE DE MEXICO. By Gamio (Manuel)—*Am. Anthropol.*, 1920, XXII, No. 2; Repr. 17 pp.

Sr. Gamio gives in this paper interesting data on the "archaic" culture of the Valley of Mexico, unmixed remains of which have lately been encountered beneath the lava flow of St. Angel. The conclusion is that they represent a traditional Otomi culture. The skeletal remains show no features that would differ from those of the actual Indian. There is no question of geologic antiquity.

LOS ABORIGENES DE LA PROVINCIA DE IMBABURA. By Jijón y Caa-maño (J.)—*Bol. Soc. Ecuad.*, 1920, IV, Nos. 10, 11, pp. 1-120, 183-244, numerous plates, bibl.

An exceptionally good and elaborate paper which, while substantially archaeological, is of interest to all other branches of anthropology.

## ANTHROPOMETRY

THE MATHEMATICS OF BIOMETRY. By Reed (Lowell J.)—*Am. Math. Monthly*, Nov. 1920, XXVII, 8°; Repr. 3 pp.

Outlines desirable methods and extent of instruction for biological and other students in mathematics.

TABELLEN ZUR UMRECHNUNG DER SCHÄDELMASSE AUF EINEN RAUMINHALT VON 1000 KUBIKZENTIMETERN. By Szombathy (Josef)—*Mitt. Anthropol. Ges.*, Wien, 1918, 8°, 220 pp.

Two hundred and twenty pages of very useful tables for those who may wish to study the measurements of the skull not as obtained, but in relation to skull capacity, a method strongly advocated by the author.

ALLGEMEINE NORMEN IM BAU DES MENSCHLICHEN SCHÄDELS. By Cohn (L.)—*Anatom. Anz.*, LIII, 1920, 433-475.

On a material of 78 human skulls from various races and of different shapes, the author found that the angles nasion-bregma-lambda and lambda-opisthion-nasion differ within the same skull on an average  $1^\circ$ , with a maximum difference of only  $2\frac{1}{2}^\circ$ . He believes that these two angles would be absolutely equal in the individual cases in all recent human races if certain sources of error in determining the points of measurement were eliminated. In Neanderthal man the proportion between the bregma and the opisthion angles equals 1.3:1; in platyrrhine monkeys it averages 1.18:1; in Old World primates it varies between 1.16:1 and 1.8:1; while in prosimiae the average is 2.3:1. The relations between several other angles of probably less importance are also discussed in this paper.

A. H. SCHULTZ.

SULL'EURIGNATISMO. By Da Costa Ferreira (A. Aurelio)—*Riv. di Antrop.*, Rome, 1919, XXIII, 237-239.

Consideration of a method for determining the prominence of the malars.

A SIMPLE TRACING APPARATUS FOR MAKING TOPOGRAPHIC RECONSTRUCTIONS. By Scammon (R. E.)—*Anat. Rec.*, XXI, No. 1.

The apparatus is devised for making graphic reconstructions of fetuses and other small specimens. It consists essentially of two parts; a glass plate ruled with a centimeter grating and supported over a base-board and an eyepiece with an optical axis established by means of an upper pinhole and lower cross-hairs. A quadrant of the base of the eyepiece is cut away to allow orientation with the lines of the centimeter grating. The margins of the quadrant are beveled and ruled with a millimeter scale for finer readings. Specimens to be reconstructed are placed on the base-board and, after orientation with the base-line of the centimeter grating, are plotted on coördinate paper by means of successive readings taken with the eyepiece.



EIN VERBESSERTES MESSBRETT. By Ried (H. A.)—*Korresp. Bl. d. d. Ges. f. Anthrop., Ethn. & Urg.*, 1920, LI, Nr. 1-4, 4 pp.

Description of interesting modifications of Broca's *planche ostéométrique*, which enable the student readily to determine also the various angles and torsions of the long bones.

LES ERREURS DUES A QUETELET. By Ledent (René)—*Rev. Anthr.*, 1920, XXX, No. 11-12, xli-xliii

On the basis of his measurements on 500 Belgian children between 5 and 15 years of age the author demonstrates that both the stature and weight of such children in Belgium have undergone appreciable augmentation, which holds true for both sexes and all the ages examined, and in consequence of which Quetelet's old standards need modification.

OBSERVATIONS CONCERNANT UNE NOTE DU DR. LEDENT SUR LES ERREURS DUES A QUETELET. By Fredericq (Léon)—*Rev. Anthropol.*, Paris, 1921, XXXI, Nos. 1-2, 56-57.

The brief paper points to some inconsistencies in a former note on the subject by Dr. Ledent, and objects to the use in that article of the word "error."

## NOTES

*School of Anthropology in Brussels.* At a meeting held on the 31st March 1919, the Anthropological Society of Brussels decided to create in that city a School of Anthropology, founded for teaching and spreading information concerning the anthropological sciences, which should be dependent on no party, but seek the goal of the unity and uplift of the nation.

There are two years of study; the first embraces general anthropology, pre- and proto-historic archaeology, linguistics and the history of religions; the second, ethnology, criminal anthropology and general sociology. The pupils pay a yearly registration fee of 15 francs, and an attendance fee of 40 francs for the course. The degree of licenciate is given after two examinations on the subjects contained in the two-years' program (registration fee for each examination 100 francs). The licenciate can then obtain the degree of Doctor in anthropological sciences by presenting an original thesis, and submitting to a public *viva voce* examination with the object of showing the results of his work (fee for the Doctor's examination 150 francs).

The professors are: General Anthropology, M. Houze; Criminal Anthropology, M. Vervaeck; Ethnology, M. Jacques; Prehistoric Archaeology, M. le baron de Loé; History of Religions, M. Kreglinger; Linguistics, M. de Reul; Sociologie, M. Wodon.

(*Rev. Anthropol.*, Paris, Mars-Avril, 1920, XXX, Nos. 3-4, 88.)

*The Institute of Human Paleontology, Paris.* On December 23, 1920, the Institute of Human Paleontology in Paris was formally declared open by Prince Albert of Monaco, its founder.

According to a recent *décret* of the *Ministry of Public Instruction of Portugal*, the instruction in biological sciences in the Universities of that country is reorganized so that henceforth it will consist of three groups, comprising respectively the botanical, the zoological and the anthropological sciences. Regular instruction will be given in anthropology proper, ethnography, criminal anthropology and prehistoric archaeology.

The Second Announcement of the *II International Congress of Eugenics* to be held in New York September 22-28, 1921, shows that the Congress is to be under the Presidency of Professor Henry Fairfield Osborn, of Columbia University and the American Museum of Natural History. The Secretary General is Dr. C. C. Little, care of the American Museum. The Congress will be organized in four sections and there will be many exhibits.

The "*Institut International d'Anthropologie*" met in Liège from July 25–August 1, 1921. An outline of a rich program for the meeting was published in the *Revue Anthropologique*, Paris, 1921, XXXI, Nos. 1–2, 61, 62.

The *Association Française pour l'Avancement des Sciences* met, August 1–6, at Rouen. The transactions of the Section of Anthropology, under the chairmanship of G. Courty, were largely devoted to Normandy.

An *International Conference of Child Welfare* has been held in Brussels under the auspices of the Belgian Government, July 18–21, 1921. The object of the Conference was the discussion of a series of questions dealing with the physical and moral welfare of children, and the rearing of infants. The discussion was arranged under four general heads: (1) Juvenile Delinquents and Juvenile Courts, (2) Abnormal Children, (3) Social Hygiene of Childhood, and (4) War Orphans.

During the past season the following papers have been presented before the *Anthropological Society of St. Louis*: "The Supracondyloid Process in Man, An Inherited Variation" by Professor R. J. Terry; "Some Copper Plaques from Missouri—a Challenge to Archeologists and Anthropologists" by Mr. J. Max Wulff; "The Neural Mechanism of Remembering and Forgetting" by Professor Edgar J. Swift; "The Relations of the External and Middle Ear to Sound Transmission" by Professor A. G. Pohlman; "The Smith-Perry-Rivers Theory of Diffusion of Culture" by Dr. Raymond Dart; "Anthropoid Man" by Professor E. H. Wuerpel; "The Psycho-Educational Clinic and the Special Classes in the St. Louis Public Schools" by Dr. J. E. W. Wallin.

"*Den Nordiske Race*" is a new semi-annual journal of race-biology and eugenics, published by Dr. Jon Alfred Mjøen of Norway. It is to supplement and "carry into life" the eugenic program of the Winderen Laboratory.

The members of the expedition organized by Mr. L. H. Dudley Buxton to investigate the physical anthropology of *Malta*, have returned to England after a stay of some weeks. About 1,000 adults, men and women, were measured, and the series of ancient bones excavated by Professor Zammit in the Hypogaeum and Hal-Safienj were also measured. Skeletal remains from a modern ossuary were examined. Mrs. Jenkinson and Miss Moss paid a special visit to Gozo to work at the physical anthropology of that island.

Man, March, 1921.

The *Carnegie Institution* of Washington has appropriated \$750 for the support of the work of Dr. S. J. Holmes, professor of zoology in the University of California, on the factors of evolution in man.

Science, March 25, 1921, 283



Professor R. J. Terry of the Department of Anthropology, Washington University, Saint Louis, has been appointed Anthropologist to the Barnes Hospital and Saint Louis Children's Hospital.

At the annual meeting of the National Academy of Sciences, Washington, April 27-29, Dr. A. Hrdlička has been elected a member of the Academy.

Dr. Davidson Black, of Peking Union Medical College, has been elected President of the Anatomical and Anthropological Association of China. Dr. Black has received also the appointment of Professor of Anatomy at the College, in succession to Dr. E. V. Cowdry who has resigned for the purpose of accepting a research position at the Rockefeller Institute in New York.

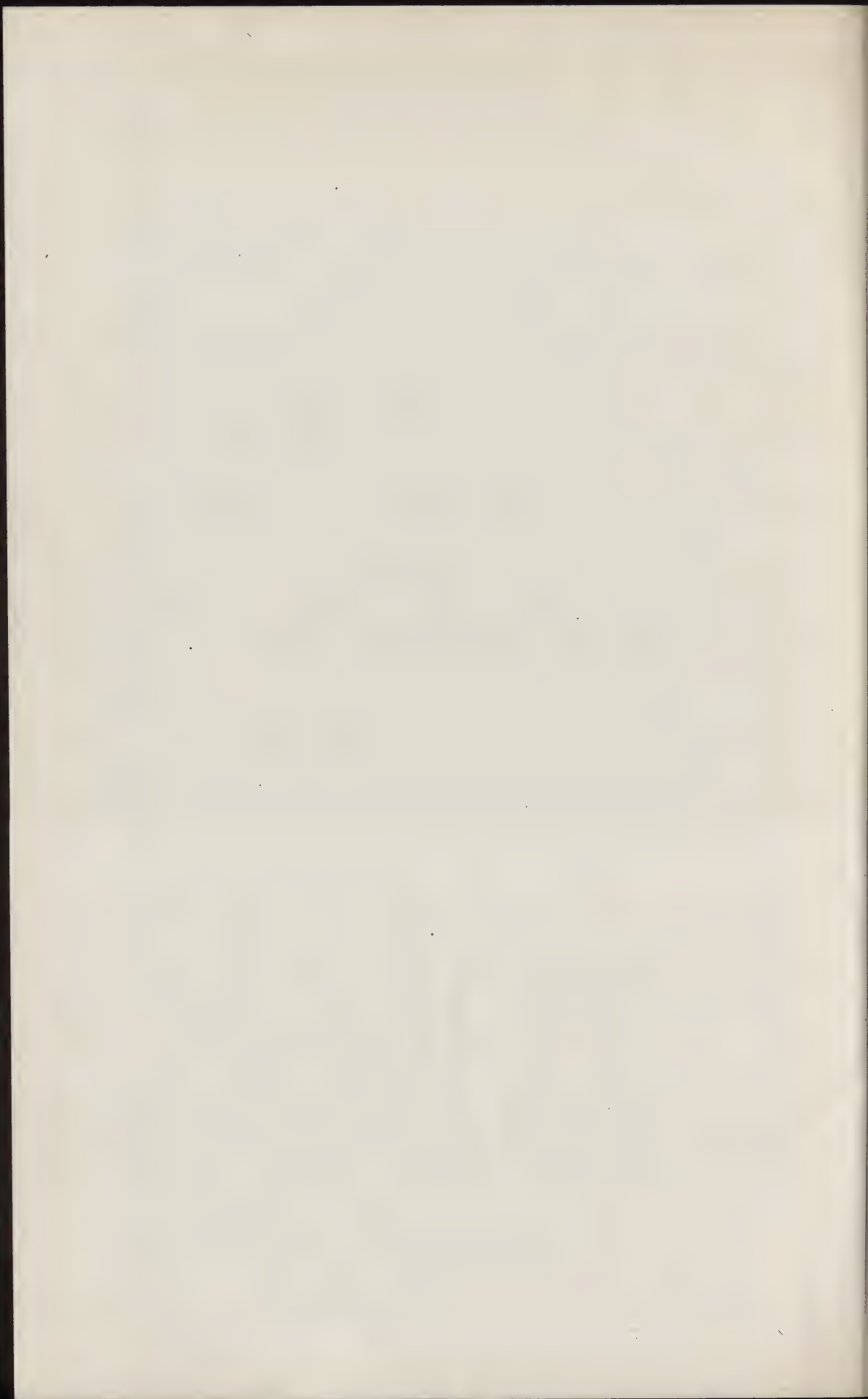
Dr. W. H. L. Duckworth, Jesus College, has been appointed to the newly-created readership in Anatomy in the University of Cambridge.

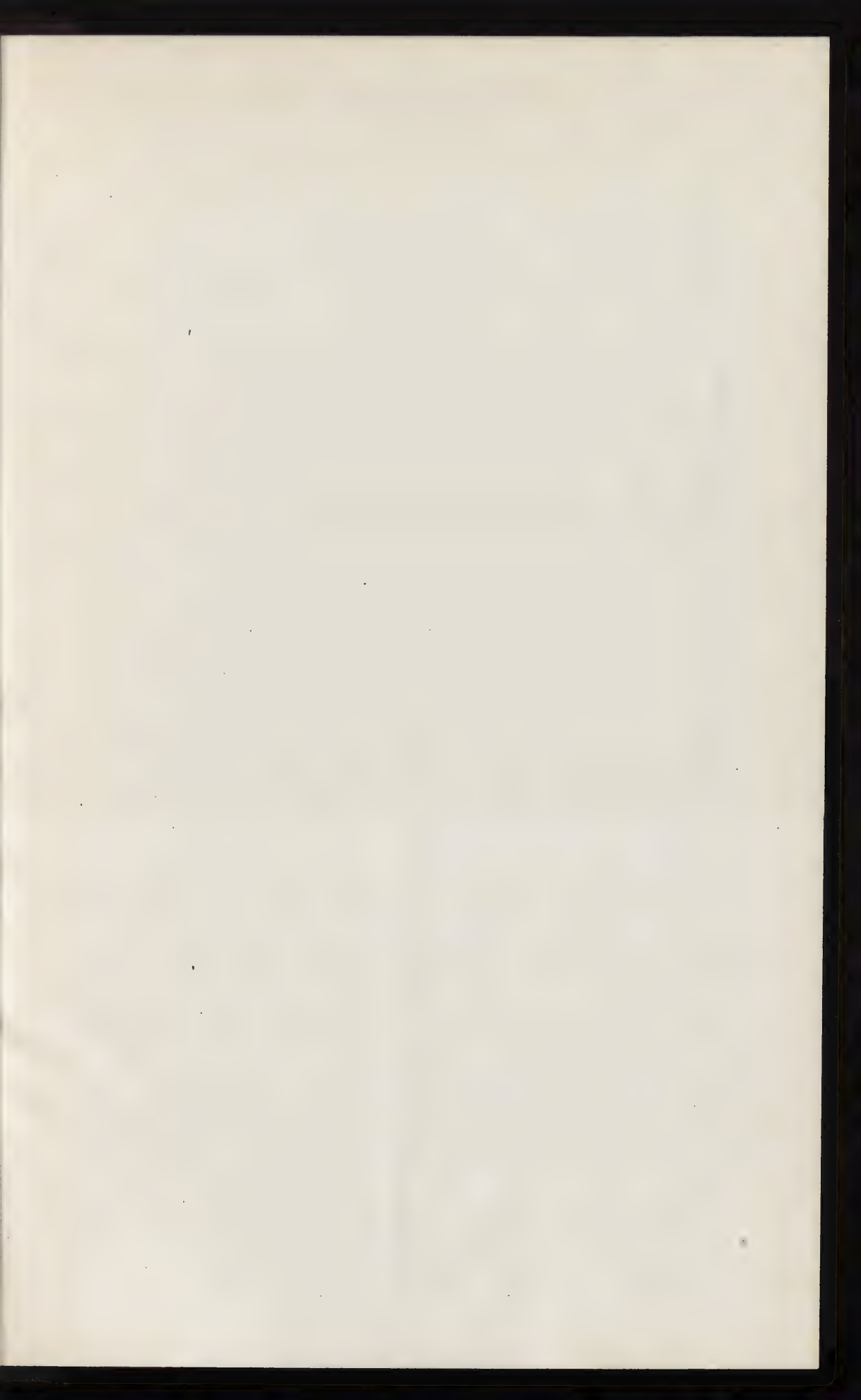
Professor J. Matiegka, Director of the Anthropological Institute of the Czech University, Prague, has been elected Dean of the Faculty of Natural History of the Prague University.

\*Wilhelm von Waldeyer, Professor of Anatomy at the University of Berlin, and the Dean of German Anatomists, has died at the age of eighty-five years. Professor Waldeyer, as practically all foremost anatomists, has always shown a friendly and even active interest in anthropology. He has contributed a number of communications of an anthropological nature, the chief among which is his well known comprehensive work on the Pelvis. He served with distinction on the committees of a number of anthropological international congresses, and has greatly furthered in Germany and elsewhere the collection of brains and their study.

\*The death is announced of Dr. Rudolf Pösch, Professor of Anthropology and Director of the Anthropological Institute, at the University of Vienna. He died on the 10th March at Innsbruck in but the fiftieth year of his life. Professor Pösch was one of the best men in the ranks of European anthropologists, and during the war has done excellent work on the prisoners of war. It seems that no science since 1914 has suffered such grievous losses in the German speaking countries as anthropology, which can hardly remain without serious effects on its future development in those countries.

\*The death is recorded in "Nature" of Miss M. A. Czaplicka, who went from Poland to Oxford in 1910 with a scholarship in Summerville College. Miss Czaplicka was well known for her noteworthy ethnological explorations among and publications on the tribes and peoples of Siberia and Central Asia. She has been lecturer on ethnology at Oxford and Bristol.









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## AGE CHANGES IN THE PUBIC BONE

### V. MAMMALIAN PUBIC METAMORPHOSIS

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## THE MAMMALIAN OS PUBIS

## INTRODUCTION

In the earlier part of this work the results obtained repeatedly impressed one with the possibility of expanding the linkages of pubic metamorphosis to include not merely Sex and Stock but also Family, Order and Class. For example in the section upon Stock-linked characters (28 p. 49) attention was drawn to significant differences between White and Negro-hybrid Stocks. In the White there is frequently an ill-marked condition or even almost total absence of the ridge and furrow system of the symphyseal face and also a very great tendency to have the ventral margin formed by gradual accretion of bone tissue instead of by a series of isolated bony nodules fusing to form bridges and later a definite rampart. In the Negro-hybrid the ridge and furrow system is much more constant and though in some cases the ventral margin is formed by simple accretion the rampart is noticeably frequent and in occasional exceptions (e. g. No. 744, see 28 Part II, p. 17) appears abnormally early. The question naturally arises as to what course in metamorphosis is the more typical of the order to which Man belongs. Does the condition in the White represent a deviation or is the Negro-hybrid progressive. One no sooner opens the problem of the Primate symphysis than one inquires what is the relation of this symphysis to that of other mammals. Whereas the os pubis of reptiles has received considerable attention the more immediate problem of the mammalian bone seems to have suffered neglect.

The stability in general of the pubis is a question well worth inquiring into. The bone bears an intimate relation in position to the sex organs which, as is clearly recognized, possess great value in the study of phylogeny. How stable the os pubis actually is in the Class Mammalia will appear later in this work.

A third question prompted by the Stock-linked characters of this bone is that of its relation to habit. In skeleton investigation one is often tempted to believe that too much has been assumed as to the effect of the erect posture in Man and that, with further investigation upon a more abundant material, some of the so-called results of the erect posture will be found to be typical mammalian age changes. One is impressed with the uniformity and the adherence to type of the mammalian skeleton in general.

It is apparent from the above sketch that no investigation of the human os pubis would have been complete had this section of the work



not been undertaken. And as we shall discover very quickly it would be impossible otherwise to grasp the significance of the variations in the human bone to which allusion has just been made.

#### MATERIAL—THE HAMANN MUSEUM

One of the most serious drawbacks to systematic work of the kind represented in this memoir is the scattered condition and relative inaccessibility of necessary collections upon which the investigation can be made. There are now in many of the great Museums vast collections of mammalian material suitable for study. Rarely can one obtain in the same Institution a corresponding collection of human skeletons in such order that individual bones can be assembled with speed and accuracy. A relatively small collection of mammals, provided it be fairly representative, and of human material, if properly prepared for systematic study, so that the worker can live with it day after day instead of having to make comparisons by memory, gives a most effective opportunity for these investigations.

In 1893, Dr. C. A. Hamann, then newly appointed to the Chair of Anatomy, conceived the plan of forming a Museum in which the normal and abnormal in human structure might be studied from clinical and comparative aspects alike. This vision led Dr. Hamann to gather and to prepare specimens upon Hunterian principles, so that in course of time there grew up in Cleveland a Museum similar in scope if not in extent to the collection formed by John Hunter. As Dr. Hamann's time became more encroached upon by practice he gave correspondingly generously in funds for the carrying out of his ideal. As one to whom there has come the privilege of assisting in the realization of this ideal and the unique opportunity of working among its treasures, I feel it fitting that acknowledgment be made at this time and at this stage in the presentation of our results. The great value of the Hamann Museum of Comparative Anthropology and Anatomy of Western Reserve University, as a center for research, must speedily become known.

It is not my intention here to dilate upon the Museum as a whole or to give an account of what has been rendered possible by the generosity of the Trustees in further financing the Department to take the fullest advantage of Dr. Hamann's gifts. I have previously mentioned the collection of human skeletons; I would now state merely that to a large extent the comparative material, both in the fresh state and as skeletons, has been gathered with especial care as to data. The skeletons are housed exactly as are the human skeletons, and every bone likewise

bears the catalogue number of the skeleton to which it belongs. Every arrangement has been made so that this collection is equally accessible with the human skeletons for comprehensive and intensive study. So far there are nearly seven hundred mammalian skeletons and skulls besides a large number of fresh examples still in the hide with which, however, we have no particular interest in this memoir.

#### LIFE PERIODS

In this work on pubic metamorphosis there are two distinct parts. In the first place we are investigating the changes which the symphysial region undergoes and in the second we are checking up these changes against time. So far as the human material is concerned it is convenient and quite intelligible to compute these changes in years. We understand perfectly well at what stage of his life period and in approximately what physical condition a human individual is likely to be if we know his age in years. The moment we begin to discuss other forms of life, however, our time standard fails us. Not only is the total period of life for almost all other animals at best very imperfectly known but the successive stages of the life period bear quite differing relations to time. Yet if we are to make any useful comparison between Man and other animals there must be some common life standard upon which the comparison may be based.

In his memoir on the Rat Donaldson (7. p. 6) makes the following statement. "The comparison of the experimental results obtained on animals with the corresponding results on man has heretofore been difficult because of the absence of a good basis for comparison. We have found reason to assume that in the case of the rat the post-natal span of life of three years is approximately equivalent to the span of ninety years in man or to put it another way, that the rat grows thirty times as fast as man. This ratio appears to hold for fractions of the span, as well as for the entire span. All of the data for the Albino, based on postnatal age, may therefore be compared fairly with the corresponding data for man." If this statement in its entirety were upheld we should be in a position to compare time relationships in skeletal metamorphosis in the Rat and in Man provided we knew exactly the age of the rat skeletons under observation. In the case of other animals we might also make the comparison provided the same information were available and in addition we knew the approximate post-natal span of life. The exact age of an individual is likely to be known in only very few animals, and these certainly not wild ones.

The approximate life span may eventually be known but there are no data available now. Chalmers Mitchell (20) has pointed out how extremely inadequate are any data existant on this subject for purposes of correlation, and further, how unwise in general it would be to assume that the life span of an animal in captivity is that of the same species in the wild state.

We may also rule out as ingenious speculations, or at best theories of no practical significance, the successive expositions from Bacon to Metchnikoff upon the relation of the life span to some particular feature of growth or structure or function. These are admirably reviewed in Mitchell's work and require no further presentation.

It appears certain that if we should have all the information called for in the two foregoing paragraphs we should even yet have no effective standard for comparison between different animals. Four years after the statement already quoted Donaldson (8 p. 301) shows that the total life span presents certain difficulties as a basis for comparison. In a discussion of skeletal growth there occurs the following significant paragraph.

"Our records do not show just how long the growth of the skeleton in weight continues in the rat, but from the data at hand we should say it was still growing at 474 days of age, which, according to our usual computation (Donaldson, '15, p. 6) is equivalent to thirty-nine years of human life. The only datum for man with which this can be compared is the linear measurement represented by the stature, which seems to reach its maximum at about twenty-eight years in the human male and twenty-five years in the female. If the increase in the weight of the human skeleton ceases at the time when the increase in stature stops, then it is clear that the growing period for the skeleton of the rat is much longer continued, and this conclusion agrees with our general impressions concerning the growth of this animal." If this be true then the total life span is of little value in comparing phases of metamorphosis in the skeletons of different animals.

The only other specific information now available relative to age changes in the mammalian skeleton apart from the usual epiphyseal features has been reviewed by Donaldson (8 p. 303). It is extremely fragmentary in scope, indefinite in time relation, and largely confined to statements of senile changes. R. M. Strong, on the other hand, is at the moment engaged on a work of great importance. Only a preliminary communication has so far been published (25), but from this it



is plain that Strong's investigation will enable exact comparisons to be made in the skeletal growth of Man, the Rat and certain birds.

Having thus exhausted every possibility of obtaining an accepted standard for comparison of skeletal metamorphosis in different mammals it became necessary to devise a method, which, however much it may ultimately have to be modified, will at least enable us to proceed with comparisons of age-relationship of skeletal metamorphosis. The absence of any standard has resulted in adoption of various arbitrary subdivisions of the life period based upon assumptions easily shown to be untenable. I do not here refer so much to the earlier period of life in which fusion of epiphyses on the long bones takes place, although our studies indicate ultimate modification of existing impressions even on this subject. I do not refer either to the terminal period of life when obviously senile features are present, but rather to the period between these two extremes. Closure of the cranial sutures, for example, is one favorite method of determining age. Parsons has thrown doubt upon the validity of this method (22), and a forthcoming publication from this laboratory amply bears out Parsons' contention. One has only to examine a series of skulls of Gorilla and Man to observe how futile must be any comparison of relative age-period based upon closure of cranial sutures. The eruption of teeth is so notoriously diversified in its relation to age that it does not even merit mention. It is unnecessary to review further standards already obsolescent.

In formulating a scheme for comparison of skeletal metamorphosis it is obviously advantageous to select standards which, although themselves skeletal, bear some general relation to the animal as a whole. They must also be features which are relatively little affected in appearance by environment, habit or morphological relationship. They must be general in their occurrence throughout the series to be compared. For this investigation they must be common to all mammals. It is not an easy thing to pick out a series of features conforming to this exacting standard and occurring at intervals throughout the total life period. We have reason to believe, however, that the limits outlined in the ensuing table have sufficiently stable relationship to the general life (not necessarily to the total life period) of the animal to serve as a framework upon which other features of skeletal metamorphosis, more variable in their age incidence, may be plotted out.

LIFE PERIOD	IN MAN	LIMITS (27).
I.	0-12 years	Terminates in union of acetabular elements.
II.	12-20 years	Terminates in union of long bone epiphyses.

- |      |             |  |
|------|-------------|--|
| III. | 20-24 years | Terminates in union of epiphyses of centra.  |
| IV.  | 24-36 years | Terminates with appearance of lipping of limb bones.   |
| V.   | 36-50 years | Commences with this lipping and terminates with the appearance of senile (quasi-pathological) erosions and osteophytic growths at joints, and with the occurrence of senile textures of bones. |
| VI.  | 50- years   | Commences with the appearance of the irregular features just mentioned.  |

Each of these features merits a full discussion and in the course of time it will become necessary to make an intensive study of them. But for the present we use these characters in an experimental manner to test their value. Later it may be found possible to expand the table and make it more complete; it may be necessary to modify it by withdrawing certain features and substituting others. In other words this table is tentative and preliminary. It is used as a proving ground for other age changes and if it prove a poor proving ground another can be substituted. The reader must not get the impression that it is permanent or immutable.

In the table I have inserted the corresponding age limits for Man to show that the periods are by no means equal in their time relationship. If periods II and III be merged as one there is a fair spacing out so far as the human life span is concerned. It would certainly be premature in the present fragmentary state of our knowledge, to assume that there is of necessity even an approximately similar subdivision of the total life span of every mammal: it may be so but proof is not yet forthcoming. Because it is particularly important that no preconceived notions creep into the work I have refrained from making any attempt to space out the life span at all equally. Hence I regard it as essential to retain periods II and III as separate intervals.

As we work through the series of mammalian pelvis upon which this study is based we shall refer each to its particular life period so that there may be some way in which we may roughly compare one animal with another in respect to the position of each individual relative to the life cycle of its own species.

#### HISTORICAL REVIEW

Metamorphosis in the region of the mammalian pubic symphysis as an age change has never received any attention so far as I have been

able to find. The morphology of the area, on the contrary, has led several investigators to lay down theories, some of which, though strictly beyond the scope of this work, nevertheless should be noted. In a series of articles Mehnert (16, 17, 18, 19) published a number of striking findings relating to the os pubis of vertebrates. Like most authors Mehnert's interest in the pubis was secondary to his desire to elucidate the pelvis as a whole. He is therefore concerned more with the reptilian pelvis than with that of mammals and in discussing the symphysial area it is the problem of the epipubis and the hypoischium which absorbs most of his attention.

In brief Mehnert was concerned with the morphology and fate of three structures, the epipubis, the ligamentum medianum and the hypoischium, lying in this order antero-posteriorly in the ventral median line of the vertebrate pelvis. Hoffmann had claimed a single median origin for the os hypoischium; Fürbringer on the contrary declared it to be bilateral originally. Mehnert in his general work upon the pelvis had investigated reptiles, birds and mammals and as the results of his investigation strongly supported Fürbringer. In his final article, with the whole of his previous experience to give maturity to his judgment, but referring particularly to the Sauria, Mehnert (19) summarizes his views in a statement of vital importance for the correct appreciation of the investigation upon which we are now engaged. I therefore quote this summary in full.

"Das Hypoischium entsteht durch Verschmelzung zweier, an den Endabschnitten der Ischia in Erscheinung tretender Zellhöcker. Anfangs steht die Cartilago hypoischium mit den Ischiis noch in einem kontinuierlichen knorpeligen Zusammenhange, welcher später schwindet durch Ausbildung einer trennenden Bindegewebszone. Das Hypoischium zeigt bei ausgewachsenen Exemplaren der verschiedenen Landsaurierspecies sehr grosse Formverschiedenheiten. Bei einigen Formen ist es ungleich rautenförmig, bald mit spitzwinkeligen, bald mit abgerundeten Ecken versehen, so dass selbst eine dreieckige Gestalt resultiren kann; bei anderen repräsentirt es die Gestalt eines Stabes, welcher entweder kurz oder lang, dick oder schmal sein kann. Das der Kloake zugekehrte Ende des Hypoischium läuft mehr oder minder spitz zu oder entsendet zwei divergirende Fortsätze. Auch die Verbindung des Hypoischium mit den Ischiis kommt auf verschiedene Art zu Stande. Bald ragt das Hypoischium mehr oder weniger tief in die Symphysis ischiü hinein; bei anderen ist dieses Ende abgerundet. Wieder bei anderen trifft man zwei Fortsätze, welche divergirend mit den Ischiis in Berührung treten. Wie auch immer das Os hypoischium gestaltet sein mag, die grösste Konstanz der Beziehungen lässt stets das Ligamentum hypoischium erkennen. Beim individuellen Fehlen eines Os hypoischium vertritt seine Stelle das Ligamentum hypoischium. Diese Inkonstanz des Os hypoischium bei ausgewachsenen Landsauriern lässt es als durchaus wahrscheinlich erscheinen, dass dieses Knochenelement, eben so wie bei der *Emys lutaria taurica* die Cartilago hypoischium, ein in der Rückbildung begriffener Skelettheil ist.



"Das Epipubis entsteht gleichfalls durch Konfluenz zweier an den Endabschnitten der Schambeine sich ausbildenden Zellhöcker. Anfangs lässt das Epipubis in seiner mehr caudal gelegenen Partie noch einen medianen Spalt erkennen, welcher später zur Verwachsung gelangt. Der ursprüngliche knorpelige Zusammenhang mit den Pubis wird gelöst durch das Auftreten einer trennenden Bindegewebszone. Dieser bei *Lacerta* eruirte Entwicklungsmodus stimmt mit dem bei *Emys lutaria taurica* und von A. Bunge bei *Triton cristatus* beobachteten Verhältnissen überein.

"Dem Ligamentum medianum pelvis kommt bei *Lacerta vivipara* keine skeletovikarierende Bedeutung zu. Es entsteht in loco nach Art eines intermuskulären Bindegewebsseptum und hängt mit diesem auf das innigste zusammen. Die Beziehungen des Ligamentum medianum zum Beckengürtel müssen daher als sekundäre gedeutet werden.

"Sämtliche in der ventralen Medianlinie gelegenen Gebilde: das Epipubis, Ligamentum medianum und Hypoischium treten ontogenetisch später in Erscheinung als die beiden primären Beckengürtelhälften, dokumentieren somit in diesem Verhalten das unverkennbare Gepräge von Sekundärbildungen.

The essence of this statement for us is that along the caudo-mesial margin of the pubis and ischium there develops a series of secondary ossifications which already in modern reptiles is prone to retrogression. Although his work on the mammals was mostly upon embryos Mehnert could not fail to be impressed with the appearance presented by the adult animal. He states (18) that a hypoischial-like bone occurs in the following lower mammals: *Macropus*, *Petrogale*, *Perameles*, *Didelphis*, *Pholidotus* and *Castor*. In other mammals and in *Monotremes* Mehnert failed to discover such a bone. The detailed consideration of the significance of this observation which is promised in the future I have failed to locate. Later we shall see that Mehnert might with advantage have carried this investigation much further.

It is curious that Mehnert should deny to the lig. med. pelvis any morphological relationship to the skeleton of the pelvis. This is criticized by Howes and Swinnerton (14) who point out that Wiedersheim described a cartilaginous tract in the adult *Sphenodon* continuous uninterruptedly with the epipubis and hypoischium. Howes and Swinnerton show that Wiedersheim's statement is an error for although there is such a cartilaginous tract originally it is already replaced by the ligament before hatching (stage R.). It would seem that Mehnert is incorrect in making such a distinction for the ligamentum medianum.

That specific ossifications occur in the tissue along the conjoint rami of pubis and ischium has long been known. Owen (2) in 1866 described a triangular ossicle wedged between the ischia just caudal to the symphysis in a young *Potorous*. Albrecht (1) in 1883 noted the occurrence of an "interpubic bone" in *Edentates*. In 1886 Anderson (2) found

Owen's triangular ossicle in a "kangaroo," in *Phacochoerus* and in *Castor* and definitely homologized it with the *os cloacae* (hypoischium) of lizards.

No real attempt was made however at a systematic investigation of the mammalian pelvis from this point of view until Parsons undertook it in 1903 (23). Parsons was stimulated by the work of Mehnert and examined the great collections in the British Museum and the Royal College of Surgeons. He misunderstood Mehnert's position and misquotes him. It will be noted that Mehnert does not state, as Parsons make him do, that epipubis and hypoischium are formed in the mid-line and are at first independent of the rest of the pelvis, but just the contrary.

Parsons discusses symphysial metamorphosis in Kangaroos and does not believe that in these animals the hypoischium ever unites with the rest of the pelvis. He considers the ossification as probably of bilateral origin. In *Ornithorhynchus* epipubis and hypoischium occur but fuse early. In Rodents and Ungulates the hypoischial element is quite distinct and the symphysis ischio-pubic but ossification in the hypoischium is bilateral and the two parts do not unite. Hence no triangular bone is formed as in *Macropus*. The inadequacy of these results clearly indicates the truth of my contention that a small representative collection efficiently arranged is of more service in investigation than a large collection in which the correlations have to be made by memory. Nevertheless Parsons leaped to the real significance of the features which he was considering and, even upon the meager human material at his disposal in London, made a true comparison with the features of the human pelvis. In this as in so many other problems, especially those connected with physical anthropology we have to acknowledge Parsons as a real pathfinder, and one who by his efforts and by pointing out the difficulties he encountered, has smoothed the way for those who follow after.

#### THE REPTILIAN SYMPHYSIS

As it is not intended to discuss the morphology of the symphysial region except as it relates to the differentiation shown in modern mammals we shall first consider the condition in the Monotremes as illustrative of the reptilian affiliation.

So far as the reptiles go *Sphenodon* is a convenient starting point. Our single specimen gives no further information than the excellent figures in the memoir by Howes and Swinnerton (14) to which the reader is referred. Plate VI Figs. 7, 8, 9, and text Figs. 13 and 14 depict the pelvis in the embryonic and the adult state. From Figs.

13 and 14 one notes that the pubis and ischium do not form a continuous symphyseal area and are separated from their fellows of the opposite side by an antero-posterior series of elements, namely the epipubis, median ligament and hypoischium. These three in the earlier stages form one continuous tract of cartilage but even before hatching the middle portion has become transformed into the ligamentous tissue of the median pelvic ligament. Neither epipubic nor hypoischial cartilage becomes ossified or shows any indication of an originally bilateral origin. I believe this single median appearance of the three elements is a secondary condition in view of the work of Mehnert. Our observations on the Mammalia thoroughly bear out such an opinion. In *Sphenodon* there is an epiphysis for the ischial tuber limited to the tuber itself.

#### MAMMALIAN PUBIC METAMORPHOSIS

Mammalian pubic symphyses may be subdivided into three groups.

1. Those in which the two pelvic halves ultimately fuse together at the symphysis.

2. Those in which, as in Man, the two pelvic halves remain separate throughout life but which articulate together by symphyseal bony surfaces.

3. Those in which the two pelvic halves do not meet at the symphysis but either are united with each other simply by a ligamentous band, the bony surfaces not touching, or are more or less widely separated and have no connection at all.

These three types bear no relation to the various orders of mammals. One would naturally turn first to the Monotremes and Marsupials and then to the Rodents and to the Insectivores with their close relations the Dermoptera and Chiroptera for information regarding the symphysis. As a matter of fact one finds that all modern examples of the two first-mentioned orders possess a symphysis of the first type and in the other group all three types are found. In the Rodentia and Insectivora there is great variation in the symphysis and in some animals a very notable specialization. Chapman (6) has recently dwelt upon this topic and it is unnecessary therefore to do more than outline his facts. In both orders three groups of pelvis are found. In the first group the pubic symphysis is rather long and represents the general mammalian condition. In the second, owing to divergence cranially or caudally of the structures entering into this formation, the symphysis is short, often extremely so. In the third the symphysis is entirely absent in consequence of the failure of the two halves of the pelvis to meet in the middle



line. The reader will note that the slight distinction between Chapman's groups and my types results from the fact that he was concerned with the two orders Insectivora and Rodentia alone, whereas my types cover the entire mammalian Class.

The reason for the marked differentiation of the symphyseal region at once attracts attention but we are not yet in position to state why one form should occur rather than another. Chapman, it is true, attempts to correlate his third group with pronounced burrowing but with this view I am not in accord. The condition in Edentates and in certain other mammals such as the Phocidae, Dermoptera, Chiroptera and even the rodent *Coendou* seems to indicate the unwisdom of drawing specific conclusions as to any true correlation with the burrowing habit. Chapman's work is especially valuable in showing the progress of specialization through his second group to his third in the Pocket Gophers and in emphasizing the lack of any precise taxonomic value in the symphyseal region.

In view of the great difficulty of obtaining the precise stages necessary to present the full history of pubic metamorphosis it will be impossible to arrange the material in acceptable phylogenetic order, and no effort will be made to follow any established phylogenetic scheme except in a very general manner.

Also, for the sake of such brevity as may be compatible with a proper presentation of the evidence, only those specimens which are of particular value in the argument will be presented.

#### MONOTREMATA

For the relation of the mammalian pelvis to that of the reptile various articles by Seeley (e. g., 24) and Broom (e. g., 4, 5) should be consulted. The plate-like formation of the combined pubes and ischia of the Permian reptiles is retained by the Monotremata (Gregory, 11 pp. 115, 154). There is a marked distinction between the pelvis of the Monotremata and that of the Marsupialia, much greater indeed than that between the pelves of a Marsupial and of a menotyphlous Insectivore.

When we attempt to refer the Monotreme skeletons to their respective life periods it appears that the arrangement of life periods presented in a former section of this paper breaks down. The Monotremata possess no epiphyses on the centra of the presacral vertebrae. This is probably a secondary condition as Gregory points out (11 p. 152) but it nevertheless removes from consideration life period III so far as

the Monotremes are concerned. The above arrangement of life periods was made for the Eutheria however and for these it holds pretty well. In what stage relative to the total life span or to the life in general the limb epiphyses fuse in Monotremata I do not know but there is at present no sufficient evidence to indicate that this differs very much from the corresponding stage in the Eutheria.

*Ornithorhynchus anatinus* B 174, is an animal before the limb epiphyses have fused. No epiphyses are to be seen on the centra of the sacral vertebrae. This is undoubtedly a young animal and its pelvis shows no fusion as yet of the successive sacral vertebrae or of ilia with sacrum. The symphysis (Fig. 1) is ischio-pubic. There is a broad mass of bone between the symphysis and the obturator foramen. No ossification has occurred in the symphysis. The epiphysis for the ischial tuber is ossified but not fused; it is limited to the tip of the tuber and does not extend along the ischial ramus.

*Echidna aculeata* B. 175 (Fig. 2), is in the same period of life as the foregoing specimen but is a considerably older animal for the sacrum is now a single bone fused on each side with the ilium. The symphysis is also ossified. For convenience we may assume that it is in the second life period. Again the epiphysis for the ischial tuber is unfused. Though it is lost from this specimen the ischial ramus on close examination shows clearly that the epiphysis extended about half way along the margin of the ischial ramus, which fact is confirmed by the following skeleton. A great change from the symphysis in B 174 is apparent. The suture between pubis and ischium on each side has disappeared and the symphysis itself is completely ossified so that the entire pelvis forms a single mass. Heaped on the front of the symphysis in the median sagittal plane is a crest of newly formed bone. Looked at with a dissecting microscope this appears to have developed independently of the pubis and ischium and to have fused with these elements secondarily. It expands at both its cranial and its caudal extremities and sinks in between the two pubes and the two ischia at these points. It is upon this peculiar dumb-bell shaped mass of bone that most of our attention will be focused.

*Echidna aculeata*, B 547, is an older animal; it is in the fourth life period. That is to say all epiphyses are fused and lipping at the joint surfaces has not yet appeared. Its symphysis bears out strikingly the features described for B 175. In spite of fusion of the epiphysis for the tuber and at the symphysis the former plainly extends half-way along the ischio-pubic ramus and in front of the latter is the separately

ossified bony rod, now one with the pelvis itself but shaped exactly as in B 175.

In the Monotremes we observe that ossification at the symphysis is completed by the appearance of two median wedges of bone, one at each extremity of the symphysis, cephalic and caudal. We note further that these two bony wedges are connected by a median bony bar lying rather on the ventral aspect of the symphysis but as in the case of its wedge-like extremities ultimately, fusing with the symphyseal part of the pelvis. This median dumb-bell shaped ossification, like the corresponding fibro-cartilaginous mass in *Sphenodon* and other reptiles, although extremely ancient, is a secondary condition in all probability.

#### MARSUPIALIA

Altogether nineteen skeletons of Marsupials have been examined with special reference to the symphyseal region, comprising all existing families and sub-families except the *Myrmecobiidae*, *Tarsipedinae*, and *Phascolarctinae* which are represented by skulls only in the collection as yet.

In accordance with our general method the age of these skeletons is recorded by reference to special phases of the life period. In the Marsupial the two halves of the pelvis are already fused at the pubic symphysis before the epiphyses of the long bones have united with the shafts, that is to say before the end of the second life period. The same condition was found in the Monotremes.

As regards dentition the fourth molars were already erupted in all specimens examined and here recorded with the exception of certain *Macropodidae* in which, as is well known there is considerable retardation in eruption of the distal molars. The exceptions then are the three following in order of age recorded by teeth and pubis.

B 192 *Petrogale xanthopus* in which the milk molar is still in position and M. 3 is just erupting:

B 182 *Macropus bennetti* in which M. 4 is appearing above the alveolus:

B 181 *Macropus bennetti* in which M. 4 is almost in position.

As already indicated no precise phylogenetic order will be followed in presenting the Marsupialia. In any case this would be unnecessary since all marsupial pubic regions are fairly uniform and typical, displaying a symphysis of pubic and ischial parts, so far as our collection goes, except in *Notoryctes* our specimen of which (B 134) is too old



to give any help in the present work. We shall consider the *Diprotodontia* first.

The first specimen is *Petaurus breviceps* B 187 (Fig. 3). This animal is in the second life period, namely before the union of long bone epiphyses. Intervening between the symphyseal faces of the two pelvic bones is a long slender dagger-shaped disc of bone, having a slight expansion above and bifurcating at its lower extremity to become continuous with the epiphyses running back to the ischial tubera. Examined from the back the two pelvic bones approximate each other, leaving merely a slightly widened gap above for the enlarged upper end of the median disc but separating widely below to admit the triangular lower end of the median disc which is plainly seen. Only the lower end however is visible from behind. The important features of this specimen are the following.

Ossification is continuous in the tissue along the ischio-pubic ramus from ischial tuber to upper end of pubic symphysis.

The ossification forms a single median bar of bone throughout the symphyseal area in which the ischia share as well as the pubes.

It consists of expanded upper and lower extremities and for the most part, forming a wedge between the pelvic bones, does not extend through the entire symphysis from front to back. As previously mentioned, the enlarged lower extremity alone is visible from behind although there is a slightly widened gap at the upper end of the symphysis.

Three specimens of *Phascalomys* give important information on the method of ossification of the median disc and its ultimate fate. The first of these, *Phascalomys tasmaniensis* B 183 has not yet attained fusion of the three acetabular elements. Here is merely a cartilaginous union at the symphysis, the cartilage in the fresh state extending along the ramus to each ischial tuber. The symphyseal face is somewhat wider in its upper or pubic portion but both pubic and ischial symphyseal faces show typical horizontal ridge and furrow formation.

The second specimen, *Phascalomys tasmaniensis* B 601 (Fig. 4), is of the second life period before fusion of the long bone epiphyses. Ossification has taken place in the cartilage along the ischial tuber but does not yet extend along the ramus. There is a small bony nodule in the cartilage at the lower end of the symphyseal area. This we shall call the lower nodule. A second small ossification occurs immediately above this but nowhere else is the median disc transformed into bone. There is a difference in the appearance of the upper, wider symphyseal face in that its ridges are larger and more irregular. A dorsal margin is developing at upper and lower extremities of the symphyseal face.

The third specimen, *Phascalomys latifrons* B 602 (Fig. 8), is also in the second life period. The median disc is completely ossified and fused with the pelvic bones which are also united with each other. No trace exists of the lines of union and barely an indication of the line of fusion of the epiphysis on the ischial tuber.

The information gleaned from the Wombat skeletons is amplified by reference to those of the *Macropodidae*. First of these we take a specimen of *Petrogale xanthopus* B 192 (Fig. 6). This example is from early in the second life period as evidenced by the obviously recently united acetabular elements. The lower nodule is well ossified and so is the epiphysis for the tuber but between these is a strand of cartilage in which no ossification exists. The bony center for the upper nodule has quite recently appeared and in connection with it a flake-like ossification has occurred in the median disc, this being visible from behind in the narrow upper gap between the pelvic bones. There is as yet no fusion of the pelvic bones together.

Next in order of sequence is a specimen of *Macropus bennetti* B 182. This time there is no vestige of the lines of union of the acetabular elements but the animal was still in the second life period. The ossifications for the lower nodule and the epiphysis of the tuber approach but still leave an intervening area of unchanged cartilage. The upper nodule is completely ossified though not yet fused with the pubic bones. From it there projects downward a flat tongue of bone, the further development of the flake seen in the last specimen, to approach an upwardly directed tongue from the lower nodule also growing at the expense of the symphyseal cartilage. Again there is no effort at fusion of the two pelvic bones.

An example of *Dendrolagus inustus* B 193 (Fig. 5) from the second life period affords opportunity to study the further development of the symphyseal ossification. In this the lower nodule is in bony continuity with the epiphysis of the ischial tuber. From the nodule ossification extends upward and just meets the down growing ossification from the upper nodule. At the mid-vertical point of the long symphysis it is evident that the ossification tends to be somewhat central in the cartilage but higher up the bony development is much greater ventrally. Indeed in this location the bone spreads out laterally so that the upper nodule lies rather on the ventral surface of the pubic symphysis although from this nodule a keel projects backward between the pubic bone and it is the hinder margin of this keel which can be seen from the back on the last specimen. A dorsal margin has grown up to delimit the sym-

physial face of the pelvic bone and is continuous throughout. Hence the stage of development is a little more advanced than that of *Phascolomys* B 601.

The succeeding phase is illustrated by *Macropus bennetti* B 181 (Fig. 7) from the second life period. The two pelvic bones are united immediately beneath the upper nodule which itself is median in position and lies on the ventral aspect of the pubic bones but is not yet united to either. The union of the pelvic bones is equally marked on both back and front but does not transgress the lower limit of the pubis in a downward direction. Ventrally the ununited portions of the pubic bones above permit a glimpse of the median tongue of bone just below the upper nodule. No such appearance is noted between the approximated but ununited ischial rami forming the lower part of the symphysis.

Specimen B 191, *Potorous tridactylus*, is at the end of the second life period for the epiphyses of its long bones are almost completely united. In this skeleton the pubic bones are wholly fused dorsally and the ischia are fusing. Both upper and lower nodules are in process of union with the pelvis and a median crest has appeared, most strongly marked on the ventral aspect of the lower nodule but still of recognizable proportions vertically throughout the entire ventral symphyseal line.

*Bettongia lesueuri*, B 598, is in the third life period. In it there is complete fusion throughout the symphysis and the ventral crest is well marked especially on what was the lower nodule. No indication of the fusion lines of any part of the symphysis remains.

From the foregoing description it is clear that in the Diprotodonts complete ossification at the symphysis and fusion of the two pelvic halves occurs before the end of the second life period. This is what we suspected in the Monotremes although because of the condition of the vertebral centra in those aberrant animals we could not be quite sure. We note that the symphyseal ossification takes the form of a somewhat dumb-bell shaped median bar lying mainly upon the ventral face of the symphysis but extending somewhat between the symphyseal faces as a thin median disc. We see also that the bar with its expanded extremities is formed not by a single center of ossification but through the fusion of a succession of median bony centers along the symphyseal and ventral margin of the ischio-pubic ramus, continuous morphologically with the ossification extending as an epiphysis from the ischial tuber. Of the several ossification centers indicated, that which ultimately forms the lower extremity (lower nodule) ossifies first. This is fol-



lowed by ossification in the upper extremity (upper nodule), and from each of these centers ossification extends in the substance of the median disc with or without the help of accessory ossification centers until complete ossification has taken place.

We turn then to the Polyprotodontia.

There is an example of *Didelphys virginiana* in the collection, B 177, in the second life period, showing ossification of upper and lower nodules slightly more advanced than the condition present in *Petrogale* B 192 above.

There is also a specimen of *Thalacomys minor* B 185, likewise from the second life period, which shows a condition intermediate between those of *Dendrolagus* B 193 and *Macropus* B 181 previously mentioned.

The general confirmation which the two foregoing Polyprotodonts give to the method and age relationship of symphyseal ossification as described for the Diprotodontia is continued by other examples.

Among our Dasyuridae there is a specimen of *Antechinomys laniger* B 190 in the second life period, showing a stage immediately following that of *Macropus* B 181 for the pubic bones are in process of uniting in the upper part on the dorsal aspect. We have also a stage like that of *Dendrolagus* B 193 in a young *Phascogale flavipes* B 189 in the second life period.

There are two skeletons of *Sarcophilus ursinus*, both curiously enough of the same stage of the second life period for both have the epiphyses of the long bones in the same state of incomplete union. Their numbers are B 178 and B 238. The stage of symphyseal ossification illustrated by these two is the same. It is just a little more advanced than that of *Petrogale* B 192 above and in conformity with this the lines of fusion of the three acetabular elements are visible only in a strong light.

A later stage is exemplified by *Thylacinus cynocephalus* B 194 for in this animal the epiphyses for the upper ends of the humeri and femora alone of the long bones are still ununited. The stage of the symphysis is somewhat earlier than that of *Potorous* B 191 for the pelvic bones are not completely fused above and below on their dorsal aspect although both nodules are uniting with the pelvis and the median vertical crest is forming.

Our other marsupial skeletons are too far advanced for the present study. *Notoryctes typhlops* B 134, it must be noted, has a pubic but no ischial symphysis. This animal is in the third life period. The pubic bones are completely fused and there is no remaining indication of the method of union. It is worth while noting that there is also no remnant of the fusion line for the epiphysis of the tuber.

Ossification at the marsupial symphysis may be summarized in the following manner. No matter what the Family, in Polyprotodonts and Diprotodonts alike, there is one type of metamorphosis and the various stages of this metamorphosis present a constant relationship to age. Practically the entire symphyseal metamorphosis occurs during the second life period, that is to say the period of union of the epiphyses of the long bones. This period commences after the fusion of the three acetabular elements. The succeeding stages of metamorphosis are quite definite. In the cartilage of the pubic-ischial symphysis there appears a bony center for the lower nodule at the point of bifurcation. This is followed by the occurrence of a bony center for the upper nodule. From each of these centers a bony tongue extends through the vertical length of the symphyseal cartilage, the mid-vertical point being the last to ossify. Ossification at the same time extends backward over the symphyseal face of the pelvic bones but the bulk of the ossification, especially above, occurs ventrally. There are now definite upper and lower median nodules united by a long flake like bony disc. At the same time the horizontal ridges and furrows of the symphyseal face become limited behind by the development of a dorsal margin to the symphyseal face which is broader dorso-ventrally in its pubic part. The median disc now fuses with the two pelvic bones which thus become united. The union first takes place just below the upper nodule. It is then carried upwards and downwards on the dorsal aspect. Later the upper nodule fuses with the pubic bones. After this the lower nodule unites with the ischia and finally the median ventral crest appears.

It does not seem important at this stage to discuss the condition of the symphyseal cartilage although there are many *Dasyuridae* in the Hamann Museum still in a recent state. These would doubtless give the successive stages for the Polyprotodontia much more completely than has been outlined above, but the material seems too valuable to use up for the illustration of a sequence already well established.

We have not so far made any comment upon the amount of participation of the ischium in the symphysis as regards Marsupials. Our specimen of *Notoryctes* B 134, in the third life period, is important in this respect. The very small obturator foramen may be taken as representing the junction between pubis and ischium. The symphysis is very short and judged by the indication just mentioned is entirely pubic.

Looking over the whole Marsupial series one is struck with the very slight extent to which the ischium actually does take part in the sym-

physis. Practically only the lower extremity is ever ischial, the rest of the surface being invariably pubic. As the description of the various orders progresses it will become obvious that this type of symphysis is the characteristic Marsupio-Placental form. From it there are variations which lead either to elimination of the ischial and shortening of the pubic portion, or to secondary increase of ischial participation. Both kinds of variation are to be found in some orders and they have no taxonomic value.

#### INSECTIVORA

One of the most important, indeed for our purpose probably the most central group of mammals is the suborder Menotyphla comprising the Oriental tree shrews and the African jumping shrews, the reason for thus emphasizing the difference in habit of the two families will shortly become clear. All the members of this suborder are difficult to obtain and we have to content ourselves as yet with two specimens of *Tupaia*, one still in the hide, to represent the whole suborder.

*Tupaia tana* B 211 (Fig. 9) is in the fourth life period, a very important stage in this investigation. The epiphysis for the ischial tuber is fused. The symphysis is long and though mostly formed by the pubic bones is completed at its lower extremity by the ischia. It is well to recognize however that the ischia play a relatively insignificant part in the formation of the symphysis. The two halves of the pelvis are not yet even beginning to fuse at the symphysis, at least behind. On the ventral aspect a long and somewhat moniliform rod of bone has developed in front of the line of the symphysis and is fusing with both sides. Above this rod expands slightly and sinks more deeply between the upper ends of the pubic bones. Below the same thing happens and this lower triangular expansion completes the symphysis caudally and is directly continuous on each side with the fused epiphysis for the tuber. The condition of the symphysis therefore which was found in the Marsupials occurs again in this animal. We have not so far begun to compare the successive stages of the mammalian symphysis in general with those of Man, but we shall see later that the stage just described corresponds with phase VI inasmuch as the ventral symphyseal margin is developing by the formation of the median bar.

The entire pelvis of *Tupaia* is strikingly like that of the Lemurs and it is because of the close ancestral relation of this animal to the Lemurs that I emphasize its importance. In spite of its being arboreal the symphysis of *Tupaia* retains the primitive Marsupio-Placental character



(Gregory 11 p. 279). This relative length of the symphysis in Menotyphla is a marked distinction from the exceedingly short symphysis, if symphysis there be at all, in the Lipotyphla. Even in *Ptilocercus*, the other member of the family Tupaiidae, according to Gregory (12 p. 249) the symphysis is "very short." Again in *Macroscelides* the symphysis is short according to Gregory's statement in 1910 (11 p. 283) though the same author describes it as long in 1913 (12 p. 249). In the absence of further information one would infer that the symphysis in *Macroscelides* is shorter than in *Tupaia* and longer than in *Ptilocercus*. One may then ask the question whether *Ptilocercus* or *Tupaia* shows the more primitive symphysis. Later we shall find that both arboreal and terrestrial forms exhibit a tendency to variation of the the symphyseal length. One might infer that the ancestral symphysis was short. The reptilian symphysis however includes the ischium to a marked extent and this condition is retained in the Monotremes. To this subject of the primitive mammalian symphysis we must return after the data are all presented but for the moment one may state the probability that both *Tupaia* and *Macroscelides* present fairly primitive and typical Marsupio-Placental symphyses. This means that the primitive Marsupio-Placental symphysis was relatively short and therefore unlike that of Monotremata in not engaging the ischia to any great extent.

Turning now to the Lipotyphla we find that the symphysis becomes exceedingly short or is even absent altogether. There is no doubt that this shortening is a secondary modification and evidence accumulates to show that there are differences in the length of the symphysis within a single species. The difference may have a certain relation to sex as in certain Rodentia (6) but it is an indication of a progressive specialization nevertheless. This is not the place for a full discussion of the problem but the reader may be referred to Gregory's notes on *Solenodon* by way of example.

"The pelvis of an adult female (Amer. Mus. No. 28271) differs markedly from one of the same species figured by Leche (1907, p. 82) in the ventral view: instead of the long symphysis pubis being present, the opposite ossa innominata are widely separated in the dried skeleton and the symphyseal region of the pubis ends in a point as in *Erinaceus*."

Our specimens of the Lipotyphla include one or more complete skeletons of the following: *Ericulus*, *Echinops*, *Hemicentetes*; *Potamo-gale*; *Chrysochloris*; *Hylomys*, *Gymnura*, *Erinaceus*; *Talpa*. All are so specialized that they are beyond the range of this discussion. At

most; as in the Erinaceidae and in Hemicentetes the symphysis consists of a fibrous band connecting the pointed cartilage covered symphyseal tips of the ossa pubis.

#### DERMOPTERA

Our single specimen of unknown sex, *Galeopithecus volans* B 544, is in the fourth life period. It represents a very short symphysis which is cartilage covered, the cartilages of the two sides being quite separate from each other. There is no ossification in either cartilage and when the cartilage is stripped off, the specimen being preserved in fluid, there is merely a rounded bony surface of cancellous tissue quite unlike the typical mammalian symphyseal face. There is no definite dorsal margin as one might expect at this stage, and certainly no suggestion of extremities or of ventral margin. It is indeed very like the condition in the Edentates soon to be presented and therefore well on the way to the condition shown in the Erinaceidae.

The markedly short symphysis is particularly interesting in view of Flower's statement that it is long and finally becomes fused (10) and again in reference to the possibility that the shortness may be a progressive specialization as suggested in the case of *Solenodon* above.

#### CHIROPTERA

Our Microchiroptera show a very specialized symphysis like that of the Erinaceidae. The progressive specialization in these animals shows a sexual difference. We have Rhinolophidae only as skulls. In these animals, which alone among microchiroptera possess a symphysis, the symphysis could give us no profitable information in the present connection. We have only skulls of the Megachiroptera.

#### RODENTIA

Reference has been made to Chapman's work on the Rodents (6) and it is therefore unnecessary to do more than remind the reader of the three groups into which Chapman divides the symphyseal of this order (see p. 343). At the moment we are concerned with those members only which still possess a fairly generalized symphysis.

It is usually claimed that both pubis and ischium take part in formation of the typical mammalian symphysis. We have noted in *Tupaia* that the ischium plays a very small rôle in symphysis formation and this view is confirmed in the case of the Rodentia by a young specimen of *Arctomys monax* B 127 (Fig. 10) in the first life period. Its im-

portance lies in the fact that, as in the case of other Sciuriforms, its symphysis is long. This great length of the symphysis is not due however to participation of the ischia in its formation. Reference to the figure shows at once that the symphysis is entirely pubic in composition. This fact should be borne in mind in the interpretation of other mammalian symphyses. It will be recalled in the section on Ungulata.

Our material referable to this order is not either very great or comprehensive, nevertheless the observations about to be recorded are extremely suggestive, when compared with the evidence culled from the Marsupials, of a difference existing between Marsupials and Rodents as representing a Placental order, in the age-relationship of pubic metamorphosis. It is well therefore to remind ourselves of the features presented by successive phases of human pubic metamorphosis. In former publications I have stated these as follows (e. g. 28 pp. 1-2).

Phase I. Typical ridge and furrow formation with no sign of margins and no ventral bevelling.

Phase II. Foreshadowing of ventral bevelling with slight indication of dorsal margin.

Phase III. Progressive obliteration of ridge and furrow system with increasing definition of dorsal margin and commencement of ventral rarefaction (bevelling).

Phase IV. Completion of definite dorsal margin, rapid increase of ventral rarefaction and commencing delimitation of lower extremity.

Phase V. Commencing formation of upper extremity with increasing definition of lower extremity and possibly sporadic attempts at formation of ventral rampart.

Phase VI. Development and practical completion of ventral rampart with increasing definition of extremities.

Phase VII. Changes in symphysial face and ventral aspect of pubis consequent upon diminishing activity, accompanied by bony outgrowths into pelvic attachments of tendons and ligaments.

Phase VIII. Smoothness and inactivity of symphysial face and ventral aspect of pubis. Oval outline and extremities clearly defined but no "rim" formation or lipping.

Phase IX. Development of "rim" on symphysial face with lipping of dorsal and ventral margins.

Phase X. Erosion of and erratic, possibly pathological osteophytic growth on symphysial face with breaking down of ventral margin.



It may be doubted how one can utilize for symphyses in which fusion of the two pelvic halves takes place the phases described for a type of symphysis in which there is permanent separation. As a matter of fact there is no great difficulty as far as phase VI. Fusion cannot occur before development of the ventral margin in one form or another. The evidence shows that in cases where fusion does occur it takes place at the stage covered by late phase VI and early phase VII. This will become clear as we proceed. It is mentioned now in order to avoid confusion. Pathological fusion on the other hand does not occur at a definite stage of metamorphosis; it may take place at any time in the life of the animal and indeed may probably be hastened by injury as in *Lemur catta* B 137 later to be described.

A specimen of *Mus norvegicus albinus* B 594 in the second life period shows a much shorter symphysis, entirely pubic, without a trace as yet of ossification of nodules, but there is quite plainly a differentiation between the articular cartilages of the two sides which meet in the symphyseal plane.

Later in the second life period when only the epiphyses at the knee and shoulder remain ununited there is still no ossification of symphyseal nodules. This is illustrated by *Mus musculus* B 287 and by other specimens which may be passed over. At this same stage however there is evidence of a growing dorsal margin very plainly seen in *Mus decumanus* B 292. One must admit then that relatively late in the second life period the Rodent symphysis has reached only phase III of its metamorphosis.

The delay in metamorphosis is not always so marked. A specimen of *Hydromys chrysogaster* B 294 in which the epiphyses of the long bones are ununited only at the shoulders and partly at the knees shows beautifully the formation of an upper bony nodule, median in position, in the cartilage of the symphysis. This lies entirely upon the ventral aspect of the symphysis. In the lower part there is a triangular nodule typical in appearance and also median in site, plainly the continuation of an epiphysal ossification along the ischial ramus from the ischial tuber. The two halves of the pelvis are not yet united. One must class this specimen in phase V of metamorphosis.

Carrying our research among the *Hystricomorpha* we find evidence that symphyseal metamorphosis is delayed in the *Myomorpha* if the evidence just cited be representative of this section of the Rodents. The very aberrant and Edentate-like pubis of *Coendou prehensilis* may be omitted for although our specimen B 263 is in the second life period

and shows no ossification at all in the symphyseal region, the form of the pubis itself suggests that whatever its metamorphosis may be it would be in no way representative of the Hystricomorphs.

Our specimens of *Erithizon dorsatus* are of the second life period but not far enough advanced to show ossification of the symphyseal epiphyses. There is however one example of *Trichys guentheri* B 264 (Fig. 11), which is quite important on account of the age relationship of its pelvis. It is early in the second life period as evidenced by the lack of fusion of the epiphyses at the elbow and also by the plainly recent fusion of the acetabular elements. In spite of its youth the dorsal margin of the symphyseal face is already completed and ossification has occurred throughout the epiphysis from the ischial tuber to the lower extremity of the symphyseal area. There is no lower nodule or any suggestion that one may ultimately form. Instead the terminal portions of the epiphyses just mentioned appear to take its place. There is no upper nodule or median disc.

The last of the Simplicidentata of the second life period to be recorded is *Dolichotis patagonica* B 267 (Fig. 12). The upper epiphyses of humeri and tibiae alone remain ununited and the epiphysis of the ischial tuber and ramus is fully ossified and united with the ischium. Its ventral extremity however forms a nodule which, together with the fellow of the opposite side, represents the lower symphyseal nodule the site of which they occupy. There is no upper nodule or ossified median disc. Nor is there any indication of a rampart or definitive margin forming at the ventral margin as might be anticipated in a bilaterally forming structure. Both this specimen and the last are in phase IV of pubic metamorphosis.

The Guinea-pig would be an interesting animal to investigate in this regard since Flower states that its symphysis remains ligamentous (10). We do not possess the necessary material for the purpose.

Passing now to the later life period of the Simplicidentata there is only one specimen which merits attention. This is *Arctomys monax* B 300 in the late fourth period. In this the pelvic bones are completely united at the symphysis and a median crest has formed. It is quite apparent still that no lower nodule has formed but that, instead, the ventral extremities of the ischial epiphyses have taken its place and terminated the symphyseal face below. The lower quarter of the symphysis is ununited behind. No upper nodule has developed but the pubic bones by some slight growth have met and fused in the median line.

The information gleaned from the Duplicidentata confirms in a general manner that just cited from observations on the Simplicidentata.

One may therefore sum up the age relationship of the Rodents in the following manner. Early in the second life period pubic metamorphosis has reached no more than phase I. Relatively late in this period phases III and IV follow each other rather rapidly. Fusion of the pubic bones occurs late in the fourth life period at phase VII. The only exception to this general rule is shown by *Trichys*. There is considerable delay in pubic metamorphosis when compared with that of the Marsupials. A further and important distinction is the tendency to completion of the symphyseal face by bilateral rather than median ossification.

#### EDENTATA

In our Edentate material the stages are missing which would show the precise method of change at the symphyseal region but we have specimens of *Manis*, *Bradypus* and *Tamandua* in the second life period with the symphyseal cartilage still uninvaded by ossification. There is one example of *Choloepus didactylus* from Costa Rica (B 275) in the third period with the pubic bones entirely fused so that no trace of the lines of fusion remains. Since the third period in the Mammalia is relatively short it is apparent that in the Edentates pubic metamorphosis passes through all phases rapidly. Though its inception is delayed when compared with the Marsupials it is completed somewhat earlier. This is what might be expected from the short and aberrant type of symphysis.

As for the precise type of metamorphosis we have no certain information in the material here but there is a specimen of *Dasypus sexcinctus* (B 276) in the fourth life period showing a suggestion of a median lower nodule in the already long fused symphysis. This lower nodule builds about half the height of the bony symphysis. It is most instructive to compare it with Albrecht's Fig. 1. (1). In Albrecht's case the entire symphyseal area was formed by an "interpubic bone" which appears to be the homologue of this lower nodule. Concerning the homology however there is not yet definite proof. Albrecht's Figs. 2, 3, 4 are very valuable in a study of the Edentate symphyseal region. From them and the text in conjunction with our material one gathers that the area is quite variously built up in this aberrant order. There may be an interpubic bone narrow antero-posteriorly but elongated transversely; or the bone may be a much smaller ossification and, as in B 276, it may not build the entire symphysis. In later life fusion takes place so completely that there is no separately distinguishable



interpubic bone at all. Albrecht's Fig. 4 shows a young *Manis* somewhat older than our young specimen. The symphyseal area in this animal possesses two centers of ossification from which combined the interpubic bone is formed. This retention of the original bilateral ossification is extremely interesting in so specialized a symphysis.

The value of the Edentates in this study is only appreciated after other orders of Monodelphia have been considered. Pubic metamorphosis is comparatively late and this is probably a very significant fact. But in consequence also of the retrogressive nature of their symphyseal area metamorphosis is rapidly completed when once begun and even the appearances of the successive phases in metamorphosis and of the bony surfaces themselves are considerably modified and retrogressive. In this respect comparisons may be made with *Galeopithecus* and with *Erinaceidae* especially *Gymnura*.

#### UNGULATA

In the remaining mammalian orders which we shall discuss there is a clear symphyseal distinction. In the Ungulates the true symphyseal face is not simply pubic in nature but is confined to the body of the pubis. The so-called ischial participation is an approximation of bony ridges rather than an articulation. In the Primates and Carnivores on the contrary there is a distinct tendency to enlist more of the pubis or even the ischium in the symphysis. We shall therefore take the Ungulates under consideration first. In these animals there is a distinct sexual relation in the shape of the symphyseal face which will be mentioned in the course of description.

Commencing with the Artiodactyla we shall utilize the Deer first because our series of these animals during the second, third and fourth life periods is complete. These periods are found to be the most important for our present study.

In the preceding pages no attempt has been made to distinguish any sex difference in the age relationship of pubic metamorphosis. In many specimens the sex is uncertain but in those in which it is definitely known sex plays no important rôle in this matter. All our American deer were given to us by the Municipal Authorities under the administration Mr. Newton D. Baker. In these as in all our other Ungulates the sex is known: it will therefore be worth while to state the sex and thus show that in these animals there is no definite sex linkage in pubic metamorphosis.

The first specimen is a male *Odocoileus virginianus* B 639 from very late in the first life period, so late indeed that there is only a small portion of the suture between ilium and ischium still remaining unfused. The third permanent molars are erupting. The symphyseal face is entirely pubic and involves the body of the pubis alone. The inferior ramus is very slender and shows no continuation of the articular surface. The ramus of the ischium which fuses with this pubic ramus likewise exhibits no articular area. The oval articular face of the pubis is broad antero-posteriorly, this being a characteristic of the male. Its dorsal margin is almost completed and the honeycombed surface adjacent is already distinctly smoother than that nearer the center of the area. The upper and lower extremities are well defined without the aid of any epiphyseal nodules, but the ventral margin is as yet unformed and instead of a honeycombed surface the pubis shows horizontal ridges and furrows adjacent to it. The appearance of the dorsal margin in spite of the other features of the symphyseal face which may result from specialization indicates that we must classify the specimen as belonging to phase III-IV of pubic metamorphosis.

Whatever doubt there may be as to the precise classification of the foregoing pelvis there can be no uncertainty regarding the two succeeding ones. These are *Odocoileus virginianus* B 649 (Fig. 14) and B 642. Both are from the second life period and possess fully erupted third molars. The symphyseal face of the former is somewhat broader than that of the latter but apart from this one description holds for both. The dorsal margin is fully formed and a narrow dorsal platform adjoins it. The extremities are well defined but there is no attempt at formation of a ventral margin of distinct outline like the dorsal. The ventral part of the symphyseal face is slightly bevelled and down it run fairly typical horizontal ridges and furrows. Both examples are clearly in phase V of pubic metamorphosis.

The next specimen from very late in the second life period, the third molars long erupted, is a young Wapiti, *Cervus canadensis* B 196. There is no difference in the symphyseal face of this specimen from those of the last two except that, being much larger, its features are more striking. That the animal was a little older is indicated by the commencing fusion of the ischial epiphysis.

*Odocoileus virginianus* B 648 is a female animal at the extreme end of the second life period. Apparently the ischial epiphysis does not fuse so early as in the Wapiti; at least in this and in the next it has not fused. The symphyseal face is narrow from before backwards, this being

typical of females. Except for the ventral part the symphyseal features are those of the foregoing. But now we see the ventral portion becoming distinctly bevelled and its texture changing to a finely granular condition. This is undoubtedly the precursor of formation of the ventral margin. It is probable that one should classify this specimen as on the border-line between phases V and VI.

The next example, namely *Odocoileus virginianus* B 634 (Fig. 13), illustrates the immediately succeeding stage. The animal is a female of the third life period whose third molars are erupted and much worn. The symphyseal face has the usual honeycombed appearance but the ridges are taking on a waxy surface which we have learned to associate with inactivity in whatever skeleton or location it is found. The lower half of the ventral margin is clearly defined by a ridge growing up in association with ossification of what corresponds to the median disc in the Marsupial. There is no attempt at fusion. When the two pelvic bones are articulated together only the pubic bodies and the lower ends of the inferior ischial rami come into contact. Between the inferior rami of the pubes and between the major portions of the ischial rami there is a long narrow fusiform hiatus. There is no indication of the lower nodule which is described in the following pelvis.

The key to these appearances is given by *Odocoileus virginianus* B 633 (Fig. 16). The specimen is a female late in the third life period. Already some fusion has taken place between the two halves of the pelvis. The fusion is not yet direct except between the lower ends of the inferior ischial rami which are united by interlocking teeth to form a suture-like line. No indication of these "teeth" was visible on the last specimen. Throughout the median vertical line of future union of the two pelvic bones there is a narrow pencil of newly formed bone, not passing backward but lying on the ventral aspect alone. It extends upward to a point halfway along the ventral edge of the symphyseal face and downwards to the area of fusion of the ischial rami which it covers in front by expanding into a triangular nodule continuous on each side with the extension of the epiphysis of the tuber. The lower nodule just described is already completely fused with the ischia. The median pencil or disc is fused almost throughout with the left side of the pelvis but on the right it is united at its extremities only. When previous writers (e. g. Flower 10) have spoken of the symphysis of Ungulates involving both pubis and ischium they have not made clear the important part played by the median pencil or disc and they have not noted that the ischial involvement is more or less supernumerary.



That the ischia readily separate will be obvious before this description of the Ungulate symphysis is concluded. Another important point which deserves emphasis is that fusion between the two sides of the pelvis is occurring directly in the case of the ischial rami, indirectly in the true or pubic symphyseal region through the activity of the median disc, at this stage which must be identified as phase VII of pubic metamorphosis.

It is this median pencil of bone, so often lost in maceration as it was in the maceration of our younger specimens, which corresponds to the real ventral margin. This median ossification occurs probably rather early in the second life period and remains separate from the pelvis itself for a considerable time after its appearance. At its lower extremity it bifurcates, one limb extending along the ischial ramus of each side. Judged simply by the unusually early appearance of this median ossification the Deer would have to be represented on the graph (Fig. 45) very close to the Marsupials. And such a position would be borne out by many of the features of the symphyseal face. Nevertheless just as we found in human exceptions that certain characters are more stable than others, so now it would seem that the extent to which the dorsal margin has developed and ventral bevelling has occurred are more trustworthy features than the precise stage at which the first ossification for the median bar is found or the very specialized face acquires delimitation of its extremities.

*Odocoileus virginianus* B 78 a male at the extreme end of the third life period, shows the complete fusion in front at the symphysis. The upper end of the median disc is, as it were, plastered over the as yet ununited ventral margins of the symphyseal faces. Throughout its length the disc is raised to form a crest and, as in the Marsupials, the crest projects in distinct promontory form from the lower nodule. Although the median disc does not extend backwards it is visible from behind in the long narrow fusiform hiatus extending from the pubic bodies above to the site of ischial fusion below and here it is the sole medium of union between the two halves of the pelvis. Unlike the preceding specimen the lower nodule actually unites the ischia in this animal and the lines of its fusion with these bones can still be traced. The only site where the pelvic bones are directly united is at the lower half of the true symphysis which, as we have seen, is formed by the bodies of the pubic bones only. In deciding upon the stage of pubic metamorphosis attained by this specimen we must take into account the incomplete ventral margin in its upper quarter and the absence of any

union of the symphyseal faces themselves. It will be recalled that only the lower halves of the dorsal margins are fused. The pelvis must therefore be assigned to the end of the sixth phase of pubic metamorphosis or the beginning of the seventh.

The Old-World deer must carry us on through the succeeding stage. The first is a male *Muntiacus muntjak vaginalis* B 607 (Fig. 15) in the fourth life period. Here the union is very slightly further advanced than in the last. The lower nodule is distinctly seen from behind and except for the absence of a median crest there is no difference in this symphyseal area from that of the last. It is definitely in phase VII.

*Hydropotes inermis* B 606 also a male in the fourth life period, shows complete fusion both in front and behind throughout the symphyseal area and is the sort of specimen which on superficial examination would lead one to suppose that pubis and ischium take equal part in the symphysis. This must be assigned to phase VII+ since we have no way of defining it more accurately at the moment.

The last part to fuse completely in spite of its getting a relatively early start is the pseudo-symphysis formed by the rami of pubis and ischium. This is shown by a specimen of *cervus canadensis* B 195 in the latter part of the fourth life period. This specimen is only slightly less advanced than the foregoing but fusion behind comprises only the true symphysis and the lower nodule whereas in front complete fusion has taken place.

We pass now to other sections of the suborder Artiodactyla and find that they confirm the observations made upon the larger material of the Cervidae. Hence a very short description will suffice.

B 469 *Dorcatherium aquaticum aquaticum*, a female of the second life period, shows a well developed margin of the symphyseal face and a dorsal platform extending over nearly one half the surface. The bevelling of the ventral margin previous to the formation of the median crest has not yet begun. The lower extremity is still indefinite. One must assign the pubis therefore to phase III.

*Tragulus javanicus borneanus* B 467, also a female but in the fourth life period shows complete fusion of the two halves of the pelvis both pubes and ischia, back and front, except at the extreme upper extremity. The median crest is forming. The specimen is therefore in phase VII.

Leaving the Chevrotains we pass to the Bovidae in the collection. There is a specimen of *Bos taurus* in the first life period (B 643) but this is a dwarf which died at two years of age measuring only forty inches in height to the withers. The symphyseal metamorphosis has been

quite precocious; the dorsal margin and platform are well developed, the ventral bevelling is present and the surface in general exhibits that waxy appearance associated with stagnation of metamorphosis. The specimen is an anomalous example of phase III and should therefore receive no further consideration at present.

Two Angora goats, *Capra hircus*, are quite important. One of these, a young male B 641, is in the second life period. The dorsal margin of the symphyseal face is just beginning to develop and massive ridges and furrows without a trace of ventral bevelling are still well shown. There is no indication of the lower extremity. The specimen is therefore at phase II. The other goat B 640 is a female at the extreme end of the third life period. There is complete fusion of the ischial epiphyses. The lower median nodule is likewise completely fused and the median disc has united the two ischial rami in front. The two pubic bones are slightly united in front only. One cannot place the specimen as more advanced than phase VI.

The last Artiodactyl to receive attention is a young male *Tetraceros quadricornis* B 603. This is in the second life period and shows a well formed dorsal margin and a dorsal platform extending over one third of the symphyseal face. There is no ventral bevelling and no sign of the lower extremity. On the contrary the horizontal ridges and furrows are very clear. The symphysis is therefore in phase III.

In all the foregoing Artiodactyls the sex character of the pubis is perfectly distinct. In the male the symphyseal face is biconvex and deep antero-posteriorly; in the female it may be concavo-convex and is always narrow from before backwards.

#### PERISSODACTYLA

Our collection of Perissodactyl pelvises is very meager but there are a few specimens which are of significance in that they confirm the typical Ungulate symphysis.

A young male *Tapirus indicus* B 262, from the second life period, has its first permanent molars erupted and shows a symphyseal face with typical Ungulate rugosity, no ventral bevelling and only the merest indication of formation of the dorsal margin. One cannot classify it beyond phase II which is probably its correct position. The ossifying epiphyses for the ischial tubera have not yet united with the main mass nor is there any attempt at fusion of the two halves of the pelvis.

Among the Equidae we have three examples, all of rather advanced stages. The first is a male *Equus burchelli* B 242, estimated from the



condition of the teeth as about twenty years or somewhat older. It is a menagerie specimen from the borderline between the fourth and fifth life periods. The pubis is biconvex on antero-posterior section, the typical condition in the male Ungulate. The two halves of the pelvis are completely fused, and in this fusion the ischia take part although, unlike the pubic bones, they present no directly articulating surface.\* There is no sign of roughness or irregularity on either front or back of the line of fusion.

That the ischia are the last to use is illustrated by a mare of *Equus caballus* B 534 of the fourth life period. This animal is a little younger than the Zebra just described: it has a pubic symphysis convex in front and concave behind. Distinct dorsal concavity is much more characteristic of the female Perissodactyl than of the Artiodactyl. Fusion in this case extends throughout the symphyseal area except in the dorsal surface of the part formed by the ischia.

Fusion of the ischia however may remain incomplete. This is shown by another mare of *Equus caballus* B 533, an animal in the late fifth life period. In spite of long standing fusion and considerable lipping of the joints the union of the ischia is incomplete in places. This is as one would expect since the relation of the ischia to the symphysis in the Ungulates is largely supernumerary.

Our only Hydracoid pelvis is from a specimen of *Procavia brucei* (B 241) of the second life period with the third permanent molars erupted. In this case the dorsal margin is forming but there is merely the first beginning of ventral erosion. The pubic symphyseal face is therefore at phase III.

It is to be presumed that there is a ventral ossification in the Perissodactyls similar to the median bar described for Artiodactyls but if so it is very small and when united with the rest of the pelvis is indistinguishable.

#### CARNIVORA

In the Carnivora we meet with a fairly generalized Marsupio-Placental type of symphysis very different indeed from the aberrant Ungulate form. The ischium takes part in the lowest portion of the symphysis but for the most part, whether it is long or short, the symphysis is formed by the pubis.

#### CANIDAE

Apart from specimens too young for our purpose the Dogs at present in this osteological collection are from the fourth and succeeding life pe-

riods. As we have already seen the fourth period is one of great importance for the study of pubic metamorphosis.

*Canis familiaris* B 96 (Fig. 20) is a male pure bred Boston Bull thirteen months old and early in the fourth life period. The symphysis is a true one throughout; there is no secondary symphysis formed. The ischium participates with the pubis and thus an elongated symphysis is formed. The dorsal margin is completed and a dorsal platform extends over the entire surface except the ventral margin which is bevelled. Neither extremity is yet delimited although the dorsal margin in its completeness gives the impression at first that both are outlined in part. The ischial tuber has its epiphysis fused and extending forwards as isolated bony nodules to the region of the future lower extremity. One would assign the specimen to phase III.

*Canis familiaris* B 110 (Fig. 22) is also a male Boston Bull. It is two years old but is still in the fourth life period. The symphyseal face now shows delimitation of both extremities and indeed the two halves of the pelvis are united by the triangular lower nodule which delimits the lower extremity. Ventral bevelling is apparent. Hence we may consider the specimen in phase V.

One might incline to suspect that the peculiar formation and development of the skeleton in the Boston Bull might have some influence upon age relationship. So far as pubic metamorphosis is concerned this is not the case for a mongrel dog B 309 and a Collie B 224 (Fig. 24), the skeletons of which are in the same general condition as that of B 110, show exactly the same features in the pubis. These also are in phase V.

A male Mastiff B 111 (Fig. 21), from the fourth life period shows the development of the ventral margin by simple ossification without the appearance of either rampart or bar. Both front and back of the symphysis are fused except for a small area at the back of the pubis. This specimen is in phase VI.

A male Collie B 128 (Fig. 23) illustrates the further stage. It is as usual from the fourth life period but ossification of the ventral margin is completed and the pelvic halves are entirely united. One must assign the pubis therefore to phase VII or possibly somewhat later.

B 403 (Fig. 25) which is a pure bred St. Bernard of uncertain age but undoubtedly senile and therefore in the sixth life period, shows beautifully the secondary changes of phase X occurring as an erosion of the ventral aspect. The specimen should be compared with B 111 (Fig. 21) in order to appreciate fully the difference between the building up and the breaking down of the ventral margin.

## PROCYONIDAE

All these examples show a typical carnivore symphysis into which the ischium enters slightly.

*Aelurus fulgens* B 254, is early in the fourth life period. Fusion of the two pelvic halves has not yet commenced but it is clear that both upper and lower extremities are formed and that very soon fusion would have begun. One may therefore conclude that the specimen belongs to phase V. The ischial epiphysis is long united.

*Cerecoleptes* (*Potos*) *caudivolvulus* B 255, is also early in the fourth life period. Again the ischial epiphysis is completely fused but here it is obvious that the lower extremity of the symphysial face is formed by an extension of the ischial epiphysis. The specimen shows the bilateral nature of this admirably. The symphysis is in the same state as that of *Aelurus*, namely the upper and lower extremities are formed but there is no completion of the ventral margin or attempt at fusion. It is in phase V.

*Bassaris astuta* B 256, is in the fourth life period. The symphysis is much as in the two previous. There is fusion however at the upper extremity. One would place this specimen at the very beginning of phase VI.

*Nasua narica* B 253, is in the fourth life period. The symphysis is fused entirely except at the upper pubic part behind. It is therefore in phase VII.

## URSIDAE

Owing to the relatively great death rate of bears in captivity during the second life period our macerated stock does not give a fair representation of the animals in the successive phases of pubic metamorphosis. Nevertheless there are certain points of general interest and importance which can be learned from this material.

*Ursus americanus* B 54, is a very young animal in the first life period after the union of the pubic and ischial rami. There is some fusion between the pubic and ischial components of the acetabulum but none between the ischial and iliac. The horizontal ridge and furrow system so well marked in older examples is not yet apparent but the general shape of the symphysial face already clearly indicates what it is to be in the adult animal. A noteworthy feature is the great length of the *pubic* symphysis. The specimen is assigned to phase I or earlier.

There are three specimens of *Ursus americanus* (B 635, male; B 636, female; and B 644, male) and one of *Ursus malayanus* (B 619), all



from the second life period after union of the epiphyses at the elbows. In each of these the dorsal margin is at an early period of its development; there is no dorsal platform or ventral bevelling. No indication of the delimitation of either extremity is to be seen. Ossification has taken place in the epiphysis for the tuber and extends forwards for a short distance along the inferior ischial ramus. It is quite clear from these specimens that the extension of this epiphysis forms the lower symphyseal extremity later on.

*Ursus americanus* B 129 is a female early in the fifth period of life. There is complete fusion of the two halves of the pelvis at the symphysis and also at the sacro-iliac joints. The epiphysis of the tuber can still be traced into the well developed lower nodule through a thinner connecting portion. No upper nodule has formed and no ventral rampart or bar completed the ventral ossification.

No sex distinctions of the symphyseal face are discernible in the Bears.

#### MUSTELIDAE

*Grisson vittata* B 646, is about half-way through the second life period. The tuber epiphysis is ossified but not yet fused; ossification does not extend beyond the tuber itself. As regards the symphysis, both extremities are still unformed and there is no ventral margin. The dorsal margin, however, is well developed. The specimen is therefore in phase III.

*Galictis barbara* B 616, is at the same stage of the second life period as *Grisson*. Its symphysis is also in phase III.

*Ictonyx lybica* B 615, is in the fourth life period. Fusion has commenced behind in the symphysis, but the ventral margin is still in process of formation. The specimen is therefore in phase VI.

*Mustela martes* B 614, also in the fourth life period, likewise has its symphysis in phase VI for it is precisely similar in condition to that of *Ictonyx*.

#### FELIDAE

In the Felidae there is no sex distinction in form at the pubic symphysis. The symphyseal face is long and extends to a certain degree on to the ischial ramus, somewhat more indeed as age increases.

At the extreme end of the first life period, that is to say when there is only a trace of the suture line between the acetabular elements left, are two skeletons, namely of *Felis leo*, B 72 and *Felis domesticus* B 64. Both show the same stage of pubic metamorphosis. The dorsal margin

is forming and adjacent to it is a narrow dorsal platform. No indication of either extremity has yet appeared. The apparent ventral bevelling is really the remnant of the ridge and furrow system. Both belong to phase III.

*Felis leo* B 334 (Fig. 18) is in precisely the same condition as the two previous examples. It is in the early second life period. We therefore assign it to phase III. The epiphysis for the tuber is ossified but the ossification does not yet extend along the inferior ischial ramus.

*Felis domesticus* B 63 is at the extreme end of the second life period. The dorsal platform has covered almost the whole symphyseal face and the inferior extremity is becoming delimited. The specimen belongs therefore to phase IV. The tuber epiphysis is now fused to the ischium but the ossification still falls far short of the lower symphyseal extremity.

*Felis tigris* B 611 (Fig. 17), is in the early fourth life period. The two halves of the pelvis are almost completely united, the dorsal ischial part lagging somewhat behind the dorsal pubic portion. The ventral margin is completed though the uppermost part has fragmented in the cleaning and the extreme upper limit seems not to unite, at least from the evidence of the next specimen. One would assign this pubis to phase VII.

*Felis leo* B 173 (Fig. 19), is in the fifth period. The symphysis is entirely united and seemingly quiescent except for the upper ventral pubic portion along the patent margin of which can be seen a well formed "rim" and the surface of which looks somewhat eroded. One must place this specimen in phase IX or possibly at the beginning of phase X. It should be contrasted carefully with B 611.

#### VIVERRIDAE

*Herpestes punctissimus* B 612, like other Carnivores shows clearly the bilateral nature of the symphyseal cartilages. The epiphysis for the tuber is ossified and beginning to unite with the ischium. The bony process does not proceed far along the inferior ischial ramus. The dorsal symphyseal margin is forming but probably there is not yet any attempt at formation of either extremity. It appears that this specimen is in phase III of pubic metamorphosis. The animal itself is in the second life period.

*Cryptoprocta ferox* B 244, is at the extreme end of the second life period. The tuber epiphysis is ossified and fused but does not extend more than half-way along the inferior ischial ramus. However the inferior symphyseal extremity is becoming defined without the aid of an epiphy-

sis and ossification is appearing in the cartilage at the summit of the subpubic arch to form a lower nodule apparently median in position. No corresponding ossification can be seen in the cartilage of the upper extremity and no attempt is being made to form the ventral margin. The specimen is therefore in phase IV. It is doubtful how far the ischium participates in the symphysis of either this or the foregoing; it certainly takes only a meager part at most while in the next specimen it takes no part at all.

*Suricata zenick* B 613, is in the third life period. It has a very short symphysis into which merely the bodies of the pubic bones enter. One might expect that its unusual dimensions would have some influence upon its metamorphosis but this does not appear to be the case. In addition to the features shown by the last, this specimen exhibits clearly the delimitation of the upper extremity but not yet of the ventral margin. One assigns it therefore to phase V.

*Viverra malaccensis* B 243, is in the fourth life period. It possesses a typical carnivore symphysis of which the pubic portion shows commencing fusion behind. There is no fusion of the ischial part at all or of the pubic portion in front. The specimen plainly belongs to phase VI.

*Arctictis binturong* B 245, is in the fifth life period. The two halves of the symphysis which involves pubis only, are completely and long fused. The symphysis is therefore at least in phase VII.

#### PINNIPEDIA

The Pinnipedia are of no value in this study for their symphysis is very retrogressive. As in *Zalophus californianus* B 637, there is no distinct symphyseal face.

#### PRIMATES

Interesting as are the symphyses of other mammals and important as we shall find them in the elucidation of the principles of pubic metamorphosis, the Primate symphysis far outstrips them in significance for the interpretation of the human form. In order then to secure a foundation for the better evaluation of the conditions found among the Primates we turn to the earliest Primate known, namely *Notharctus* of the Eocene. Unfortunately the symphyseal area is not yet known in this animal but from Gregory's important and detailed monograph we gather the following significant information.



"The whole configuration of the pelvis of *Notharctus* indicates that the animal was an arboreal quadruped which did not sit fully upright but leaped about on all fours among the branches. . . .

"The pubis of *Notharctus* is not preserved, but from the close similarity of both the ilium and the ischium to those of lemurs, it is quite likely that the pubis was less extended antero-posteriorly than it is in *Cebus*." (13 p. 86)

"With regard to the postcranial skeleton the writer has made a very large number of comparisons between the vertebrae, limb and foot bones of modern *Indrisinae* with the homologous parts in the Eocene *Notharctinae*, with the invariable result that the conditions in the *Notharctinae* seemed to be evidently more primitive, potentially ancestral to the specialized conditions observed in the *Indrisidae*." (13 p. 216)

Now on our specimens of *Cebus* the symphyseal face covers the pubic body and extends only slightly on to the pubic ramus. It is not so extensive as in *Ateles* and other New World Monkeys. The area occupied by the symphyseal face in *Cebus* is very much the same as in our Lemurs except that in some of them it is limited to the pubic body. The only pelvis of the *Indrisinae* which we possess as yet is that of *Indris*, but this is a more specialized animal than *Propithecus*. Our *Indris* has a symphyseal face which covers both the body and ramus of the pubis and even doubtfully extends on to the ischium. This elongation may well be related to the different posture and loss of the tail. At any rate comparison of Milne Edwards' figure of *Propithecus verreauxii* with our *Indris indris* shows that the symphysis is much shorter in the former. We may take it then that the symphysis of the ancestral Primate was short, probably confined to the body of the pubis or but slightly extending on to the pubic ramus, and that its original limitations are fairly well preserved in modern Lemurs. With this background we may proceed to the consideration of the symphysis of modern Primates.

In the nomenclature of the Primates we shall endeavor to avoid confusion by adhering strictly to the nomenclature adopted by D. G. Elliott in his monograph upon this order (9).

#### LEMUROIDEA

In the consideration of Lemuroidea it will be of advantage in this work to take first the *Galaginae*, *Lorisinae* and *Tarsiidae* for in our examples of these the symphysis does not more than cover the pubic body whereas in the other members of the suborder it tends to extend on to the pubic ramus also.

Our *Microcebus murinus* Miller B 434 (Fig. 26) is a male in the second life period and by no means near the later part of that for the epiphyses around the knee joint are not yet united. In spite of this the tuberous epiphysis is completely fused. The dorsal symphyseal margin is completely formed and the horizontal ridges and furrows are entirely obliterated by the dorsal platform. Upper and lower nodules are present and large but no rampart has yet appeared upon the ventral bevelled area. One must assign this animal to very late in phase V of pubic metamorphosis. Why it should differ so strikingly in age relationship from the other Lemurs I have no suggestion to offer at present.

In this animal, as already indicated, the symphyseal face extends over the pubic body only. It is a very important specimen and probably indicates fairly closely the manner of pubic metamorphosis in the typical Primate. It is probably a more primitive form of pubic metamorphosis than any other specimen so far presented in this memoir.

*Nycticebus borneanus* Lyon B 136, a male at the extreme end of the second life period, shows an epiphysis for the ischial tuber in process of uniting. This epiphysis is ossifying as a narrow needle of bone along the subpubic arch but the ossification has not yet reached the pubic ramus itself and is therefore still far from the very short symphyseal area. The dorsal symphyseal margin is forming but there is no indication of either extremity and the ventral region shows only bevelling. The specimen is therefore in phase III. The symphyseal face is limited to the pubic body and indeed does not cover all of that; it reminds one rather strongly of the Edentate symphysis.

Our single example of *Tarsius borneanus* Elliott B 135 is from the fourth life period. The dorsal margin of the symphyseal face is well formed but there is no sign of commencing fusion of the two sides together. The ischial epiphysis is already considerably ossified but not yet united to the tuber. As an attenuated ridge fused with the main bone it extends along the subpubic arch and its continuity with the well ossified lower nodule is clearly discernible. The lower nodule is quite separate from its fellow of the other side and completes the lower extremity of the symphyseal face. The upper nodule is also well ossified though, like the lower, it is not yet united to the pubis. It forms the upper extremity of the symphyseal face. Ventral bevelling is plainly visible through the translucent cartilage but no indication of the ventral margin or rampart can be seen. The specimen is therefore in phase V. of pubic metamorphosis. Note that *Tarsius* has a short symphysis limited to the pubic body only.

## LEMURINAE

Among the Lemurinae there are several examples. *Lemur* sp. B 138 (Fig. 28), is from the extreme end of the second life period. Again the symphysis is limited to the pubic body. There is commencing formation of the dorsal margin but no sign of the dorsal platform; the horizontal ridges and furrows remain unchanged. Neither extremity has begun to develop although the continuity between the lower nodule which has yet to ossify and the epiphysis for the ischial tuber can easily be made out along the subpubic margin which is still cartilage covered. Ventral bevelling has not begun. Symphysial metamorphosis has only reached phase II.

*Lemur catta* Linnaeus B 197, is a female in the fourth life period. The dorsal margin of the symphysial face is completely formed but the lower extremity is just commencing to define itself in spite of the long completed union of the tuber epiphysis. There is no indication of the upper nodule or extremity and from the ventral bevelled area no rampart is arising. The symphysis is therefore in phase IV. It extends over the pubic body and slightly on to the pubic ramus.

*Lemur variegatus* Kerr B 344 (Fig. 29), is a female in the fourth life period. The dorsal symphysial margin is completely formed. There is no union between the two sides of the pelvis. The new bone which has recently developed to build up the upper and lower extremities and the ventral margin is clearly distinguishable but the last mentioned is not completely formed. The epiphysis of the ischial tuber is long united. One must place this specimen in phase VI of pubic metamorphosis. The symphysial face extends over a small part of the pubic ramus in addition to the body.

*Lepidolemur ruficaudatus* Grandidier B 345, is a male in the fourth life period. Ossification and union are not yet complete in the epiphysis along the subpubic margin. The dorsal symphysial margin is complete; the lower extremity is forming and bony nodules appear along the line of the future ventral margin although these have not yet fused with the main bone. No sign of the upper extremity has appeared. Nevertheless the specimen is in phase VI of metamorphosis. The symphysial face scarcely encroaches on the pubic ramus.

*Lemur catta* Linnaeus B 137 is a male in the fourth life period which in earlier life suffered a fracture of the pelvis with good union but deformity. The pubic symphysis has been somewhat forced apart and fusion between the two sides has taken place but is anomalous in



its type. One must place it in phase VII. It is doubtful if this symphyseal face extends on to the pubic ramus.

The foregoing specimens from the Lemurinae show that the greater part of the symphyseal change occurs during the fourth life period. At the end of the second period symphyseal metamorphosis is still in phase II; at the beginning of the fourth life period it is no further than phase IV but during this period all phases are passed through up to and including fusion which we have found commencing in other mammals late in phase VI. In the Lemurs it is pretty clear that fusion does not take place until phase VII. Reference to the graph of age relationships in pubic metamorphosis (Fig. 45) indicates that already in the Lemurs we see the same characteristically Primate age relationship which is found in Man.

In confirmation of the general statement of age relationship rendered possible by examination of the Lemurinae the following observations are recorded.

*Indris indris* Gmelin B 343, is a male from the fourth life period. The tuberous epiphysis is long united. The dorsal symphyseal margin is formed and the dorsal platform has obliterated all indication of the original ridges and furrows. There is pronounced ventral bevelling but no suggestion of a rampart. The upper extremity is not yet defined and the lower extremity is barely indicated. The specimen is therefore at the very beginning of phase IV. It is further noteworthy that in this animal the symphysis extends secondarily downwards to include part of the ischium and that the lower extremity is forming without the intervention of a nodular ossification. This is possibly related to difference in posture and loss of the tail. The symphyseal face in *Propithecus* does not extend so far.

Our example of *Daubentonia madagascariensis* Gmelin B 198, is a male in the fourth life period and shows a fairly typical lemuroid pelvis in all respects. The symphysis is rather long as would be expected from the sex but though it involves the pubic ramus it does not encroach upon the ischium. The tuberous epiphysis is long united and the dorsal symphyseal margin is well formed. The lower extremity is formed by a sharply outstanding continuation of the tuberous epiphysis. There is no sign of a special upper nodule but there are indications that the ventral margin is about to commence upon the ventral bevelled face. The specimen should therefore be allotted to phase V.

## ANTHROPOIDEA

In the Platyrrhine group we have no pelvises of the Hapalidae. The following observations therefore apply only to the Cebidae.

## CEBIDAE

*Ateles belzebuth* E. Geoffroy B 141, is in the early part of the second life period. It is probably a young male. The tuberos epiphysis is not yet ossified but the extension of the cartilage along the subpubic arch into the symphysis is very plain. The symphyseal face itself still shows the typical horizontal ridges and furrows of the adolescent stage and even the dorsal margin is scarcely attempted. There is no ventral bevel. We assign the specimen to phase II of pubic metamorphosis. The symphyseal face involves pubic body and ramus but probably does not extend on to the ischium.

*Cebus unicolor* Spix, B 142, is also in the earlier part of the second life period but is slightly older than the last and the tuberos epiphysis is ossified over the tuber itself. The ossification does not extend along the subpubic arch. It is probably a female. The dorsal symphyseal margin is well formed but there is no ventral bevel or any indication of either extremity. The specimen belongs therefore to phase III. Its symphyseal face involves the pubic body and extends slightly on to the pubic ramus.

*Aotus gularis* Dollman (*Nyctipithecus trivirgatus*), B 342, is again somewhat older than the *Cebus* and is estimated to be in about the middle of the second life period. It is a female showing ossification of the tuberos epiphysis, the ossification extending along the subpubic arch almost to the lower symphyseal extremity. The dorsal symphyseal margin is well formed but the upper and lower extremities and the ventral margin have not yet defined themselves although there is considerable recent addition of bony tissue in the neighborhood of the upper extremity as in the last specimen. We still assign this animal then to phase III. The symphyseal face is long; it involves pubic body and ramus, possibly extending slightly on to the ischium.

*Alouatta palliata* Gray, B 340, is stated to be a male although the pelvic features distinctly indicate female. It is in the very beginning of the third life period. The tuberos epiphysis is entirely ossified and partly united over the tuber itself. Along the subpubic arch the ossification extends as far as the lower symphyseal extremity. Of the sym-

physial face itself the dorsal margin is well formed but there is no indication of upper or lower extremity or of ventral margin and there is not much ventral bevelling. The symphysis is in phase III. The symphysial face involves the pubic body and to a slight extent the pubic ramus.

*Cebus* sp., B. 146, is an animal in the third life period. The epiphysis of the tuber is ossified and fused. From it an extension runs along the subpubic arch but does not reach far. In this specimen the symphysis is entirely pubic and only involves the pubic ramus slightly. From the true symphysis there extends downward an imperfectly ridged narrow strip along the pubic ramus as far as the ischial ramus. In later life this covered by an extension of the ossified ischial tuber epiphysis. This imperfectly ridged strip is characteristic of the Primate above the Lemurs and more extensive reference must be made to it later. On the true symphysial face the dorsal margin is well formed and the dorsal platform has obliterated the ridges and furrows except in the ventral area which shows the commencement of bevelling. As yet there is no indication of either extremity. One therefore assigns the specimen to phase III.

*Saimiri* (*Chrysotrrix*) *oerstedii* Rheinhardt, B 341, a female in the fourth life period, shows complete fusion at the symphysis behind but not in front where the ventral margin is not yet completed. The animal is therefore in phase VI of pubic metamorphosis. The symphysial face involves only the pubic body.

#### CERCOPITHECIDAE

Passing now to the Old World Anthropeida we glance over the age relationship of the Cercopithecidae before discussing the Anthropoids.

*Pithecus rhesus* Audebert, B 150, is an animal in the first life period. In its symphysial area the horizontal ridges and furrows are not even well developed. It is not later than phase I. The symphysial face involves pubic body and ramus.

*Pithecus rhesus* Audebert, B 460, is a female also in the first life period but at the very end for the acetabular elements are in process of uniting. The true symphysis is quite short and is entirely on the body of the pubic bone itself. But from this there extends downward a secondary, roughly ridged narrow prolongation encroaching upon the ischium. The distinction between these two parts of the symphysis has not appeared in the foregoing specimen. It is striking in itself but an additional peculiarity is its transient character. In part at least it is covered by the ischial epiphysis.



*Pithecus rhesus* Audebert, B 148, not quite so old as the foregoing, shows a practically similar condition. The two may therefore be considered together. The dorsal margin is already fairly well formed and there is an adjoining dorsal platform. There is no definition of extremities and no ventral bevelling. The phase of metamorphosis is therefore III. The narrow ridged prolongation extending as far as the ischium occurs here also. The symphysis extends over the pubic ramus.

*Pithecus nemestrinus* Linnaeus, B 337 (Fig. 27), is a male at the extreme end of the third life period. The epiphysis for the ischial tuber is now ossified and completely united. The characters of the symphyseal area are those just described for B 148 and B 460 except that the lower extremity is forming without the intervention of an epiphysis and the horizontal ridge and furrow system on the face itself is entirely obliterated. The quite secondary nature of the considerable ischial symphysis is clearly shown by its patchiness and irregularity. The specimen is already in phase IV.

*Lasiopyga mona* Schreber, B 147 (Fig. 31), is a male also at the extreme end of the third life period but in this animal the symphysis is already fused throughout both the true pubic and the secondary ischial portions. We must therefore assign the specimen to phase VII and take up its anomalous position later. (The last vertebral epiphyses in Primates to fuse are those of the lumbar centra: this animal has already slight spondylitis in upper thoracic region—prolongation of period III?.)

*Papio hamadryas arabicus* Thomas, B 151, is in the fourth life period but the condition of its ischium and symphysis is exactly the same as that of *Pithecus nemestrinus* B 337 above.

Among the *Semnopithecinae* two skeletons should receive attention. Of these the first is *Pygathrix entellus* Dufresne, B 158, a female in the later part of the second life period. Its condition, so far as ischium and symphysis go, is again exactly that of *Pithecus nemestrinus* B 337 except that the lower extremity is less clearly defined. It is at the very beginning of phase IV.

*Pygathrix rubicunda* Müller, B 622, is another female but this time in the third life period. The symphyseal condition is slightly more advanced than that of the last for fusion is beginning between the secondary ischial isolated areas and also in the dorsal part of the true pubic symphysis. The specimen must be placed in phase VII.

From the foregoing survey, fragmentary though it is, we may obtain a very distinct picture of the age relationship of pubic metamorphosis

in the Primates below the Anthropoids. This is represented in detailed form in the graph of the Primates (Fig. 45). In an earlier part of this work (28) I have divided the several phases into three periods. The first includes the post-adolescent phases I, II, III; the second comprises phases IV, V, VI which cover the various processes by which the symphyseal outline is built up; the third unites phases VII, VIII, IX, X which typify gradual quiescence and secondary change. In the detailed Primate graph it is seen that the initial phases I, II, III are thrown progressively earlier in relation to the general life periods but that phases IV, V, VI and VII remain much more constant in their age relationship.

#### SIMIIDAE

In considering the Anthropoids we shall find it most satisfactory to review the giant black Anthropoids—the Gorillas and Chimpanzees—together and first; together because in pelvic form they are very much alike, and first because we have a fairly representative collection which will readily give a standard for comparison with the pelves of the other Anthropoids.

#### GORILLA AND PAN

*Pan satyrus* (Stated to be *Troglodytes niger*), B 168, is a quite young animal in the first life period. There is no attempt at union of the acetabular elements nor any ossification of the epiphysis of the tuber. The symphyseal face shows merely the horizontal ridges and furrows typical of the young animal. One may consider it in phase I as one does not yet know at how early an age phase I appears. The symphyseal face extends over the pubic body but doubtfully on to the pubic ramus.

*Gorilla* sp. B 169 (Fig. 33) is in precisely the same condition as regards general skeletal and local symphyseal features. In both animals there is a complete milk dentition undisturbed by the permanent teeth. Both would be about two years old upon Keith's computation. (15)

*Pan* sp. B 347, is an animal in which the permanent dentition is erupting. The third molars have not yet appeared and the milk canines are still all in place. There is no indication of fusion of the acetabular elements nor of ossification of the epiphysis for the tuber. The dorsal symphyseal margin is forming and already the dorsal platform has largely obliterated the ridge and furrow system. There is no indication of ventral bevelling or of either extremity and the symphyseal face is

continuous with the cartilage covered area extending from the ischial tuber. Indeed one cannot be sure that the symphyseal face does not extend slightly on to the ischium. The specimen is in phase III.

Pan sp. B 346 (Fig. 35) is a rather older animal since the milk canines are shed preparatory to the eruption of the permanent teeth. Also there is commencing fusion of the acetabular elements and some slight ossification of the tuberous epiphysis. The dorsal margin and platform are very little advanced beyond the condition in the last. Ventral bevelling has not yet commenced and the extremities are undefined. Indeed the symphyseal face is continuous with the ramal cartilage covered surface as in B 347 and therefore may be considered to encroach on the ischium. This specimen is also in phase III.

Pan sp. B 540 (Fig. 37), is at the extreme end of the first life period. The acetabular elements are partly fused. The secondary symphyseal extension along the ischio-pubic ramus is very clearly marked and slightly involves the ischium. The dorsal margin of the true symphyseal face is largely completed though the dorsal platform is still somewhat small. There is no ventral bevelling and the extremities are not defined. The specimen is therefore assigned to phase III.

Pan sp. B 461, is an animal in which there only remains unfused the ilio-pubic component of the acetabulum. The symphyseal condition and extent is the same as in the last. This specimen must also therefore be assigned to phase III.

Pan sp. B 459, is early in the second life period. The epiphysis of the ischial tuber is much more ossified and is even partly united to the main bone. It does not yet extend more than half way towards the lower symphyseal extremity. The symphyseal condition and extent is unchanged from that of the last. This pubis is classed as phase III.

Pan sp. B 458, is in the second life period. The ischial epiphysis is completely ossified and united; it extends as far as but does not encroach upon the lower symphyseal extremity which is now distinctly becoming defined. Ventral bevelling is also apparent but the upper extremity has not become outlined. The specimen is therefore in phase IV. The symphyseal face encroaches on the ischium slightly.

Gorilla sp. B 626 (Fig. 34), a female of the third life period, is markedly aberrant for despite its youth the entire symphyseal outline is completed and there are even indications of a "rim." There is also considerable ventral secondary excavation. This specimen must be assigned to phase IX and classed as an anomaly to be further investigated. A further evidence of its anomalous condition is indicated by the



fact that the symphyseal face is unusually short and extends over the pubic body but only slightly involves the pubic ramus.

Gorilla sp. B 624 (Fig. 36), is a very large male in the fourth life period. Dorsal margin and both extremities are all defined though not strikingly. The dorsal platform and the ventral bevelling have obliterated almost all trace of the ridge and furrow system. A ventral rampart has formed but the ramparts of the two sides are fused together in the middle line to form a single median bar, long, narrow and wedge shaped with its base above. This bar scarcely penetrates between the symphyseal faces at all. It is strikingly reminiscent of the corresponding bar—the median disc—found in Marsupials. The specimen must be classed in phase VI. No greater divergence could be found in the detail of pubic metamorphosis than between this and the last specimen. Whereas had this animal lived a little longer, the two halves of the pelvis would have been fused at the pubic symphysis, B 626 has completed its metamorphosis without fusion and apparently without the occurrence of a median bar. These two specimens are the key to the varied appearances which we are about to encounter in the Anthropoids of later life periods. The symphyseal face as in the last is rather short. It involves pubic body and ramus.

Pan sp. B 543 (Fig. 38) is specially interesting in contrast with B 624, for it shows the completion of the oval symphyseal outline without the assistance of a median disc. The animal was in the fourth life period. The oval outline is complete as just stated but neither extremity is well defined. There is no suggestion of the "rim" which appears later in its lower half but in the upper half it is rough and gives the appearance of a possible approaching fusion. Such a result must not be predicted as being the necessary consequence for irregularity like this is not infrequent after fifty years in Man in whom there is no union. B 543 should not be compared, however, with Man in his sixth life period. Further this irregularity is ventral though it does not encroach upon the ventral margin itself. Secondary erosion appearing first on the symphyseal face is rather more dorsally placed. Even comparing B 543 with other specimens of Pan and Gorilla it is obvious that great irregularity need not call for ultimate fusion. The ventral margin has been formed in this specimen directly from the underlying bone. No median disc has been built nor has any attempt been made to form a ventral rampart. The condition of the symphysis in short is precisely similar to the majority of human examples and is assigned to phase

VII. The symphyseal face involves the pubis only and does not extend quite to the ischium.

Sometimes, on the contrary, fusion does occur and a very instructive specimen in this regard is *Gorilla* sp. B 239 (Fig. 39) a female in the fourth life period. As in the last the oval symphyseal outline is formed but the extremities are not well defined. The ventral margin has apparently grown up simply by additions to the pubic body itself; there has been no ventral rampart. The growth of the ventral margin however has been quite vigorous and the two pubic bones have just begun to fuse midway along this margin at its extreme ventral edge. In the course of preparation the union has been broken down. Dorsal to the area of fusion is the same irregularity found in the last specimen; only there is in B 239 a somewhat vigorous growth of new bone in the irregular area. This is completely lacking in B 543. The symphyseal face involves pubic body and ramus only.

*Pan* sp. B 629 (Fig. 41), again from the fourth life period, shows complete fusion of the pelvic bones throughout the pubic symphysis. The union has occurred last in the dorsal part and there is no very clear indication of the presence at one time of a median ventral bar or disc. The symphyseal face extends over only a part of the pubic ramus.

The three foregoing specimens may all be considered as belonging to phase VII.

*Gorilla* sp. B 627 (Fig. 43) a female of the fourth life period is of the non-fusing type for although the oval symphyseal outline is completed and the extremities are becoming defined there is no vestige of a median disc. The symphyseal face is practically smooth and quiescent and should be assigned to phase VIII. The bony ridge for attachment of *M. gracilis* is well developed in this animal, an unusual condition for even the Anthropoid. The extent of the symphyseal face is as in B 629.

*Pan* sp. B 630, in the fourth life period, is very like the last. The oval outline is complete and the extremities are well defined; the surface is quite quiescent but there has been no attempt at fusion. The *gracilis* ridge is not developed at all in this animal whose os pubis must be considered in phase VIII. The symphyseal face extends over part only of the pubic ramus.

*Pan* sp. B 628 (Fig. 40), in the fourth life period, is almost a reduplication of B 630 and must also be assigned to phase VIII. The symphyseal face is as in the last.

*Pan* sp. B 171 (Fig. 42) is a most valuable specimen for it illustrates the Anthropoid in the late fifth or early sixth life period. The oval

symphyseal outline is complete and there is almost a "rim" formed. The symphyseal face itself is markedly irregular from secondary erosion the character of which is entirely different from the condition in such specimens as B 543 and B 239. The dorsal margin is distinctly lipped and from the ventral area there is a considerable outgrowth of new bone. This stimulates somewhat the "bearded" condition of old human symphyses and should be classed in phase X. The symphyseal face barely extends even on to the pubic ramus.

#### PONGO

*Pongo pygmaeus* Hoppius B 164, is a very young animal at the completion of eruption of the milk dentition. Its os pubis is in phase I or earlier depending upon how far back in the childhood of Man and other mammals one can find a definite pattern in the symphysis. The animal is of course in the first life period. The symphyseal face involves pubic body and ramus only.

*Pongo pygmaeus* B 625, an older animal although still in the first life period, has the milk canines and upper second milk molars in position. Otherwise the dentition consists of permanent teeth and includes the first and second but not the third molars. There is no attempt as yet at union of the acetabular elements although the acetabular rim is distinctly forming. The dorsal symphyseal margin is growing and there is even a suggestion of a limited dorsal platform so that the symphysis must be assigned to the border line between phases II and III. The symphyseal face has the same limits as in B 164.

*Pongo pygmaeus* B 623 (Fig. 44) is a male in the fourth life period. The dorsal margin and dorsal platform are well shown. The extremities are not very clearly delimited; the ventral margin is appearing and it is most instructive to examine the specimen closely for it shows admirably how this grows by gradual accretion without the development of a rampart, commencing from below so that the upper part is the last to form. It is therefore in phase VI. The symphyseal face does not extend quite so far as to include the ischium.

Our last specimen is *Pongo pygmaeus* B 172. This is a still older male in the fourth life period. The symphyseal outline is completely formed and the symphyseal face is quiescent. There is even an indication of a future "rim" round the margin. No ventral rampart has appeared but the ventral margin has grown up by gradual accretion as in the majority of human pelves. One must assign this specimen to late phase VIII. The symphyseal face involves only pubic body and ramus.



The record of the Orang, so far as it is indicated by our examples, is quite in harmony with that of the Gorilla and Chimpanzee. We now pass to the Gibbons.

## HYLOBATES

*Hylobates concolor* Harlan (*mülleri*) B 162, is a quite young animal at the change of dentition. Some of the permanent incisors and the first permanent molars are erupted. The symphysis is of the usual juvenile type which we have classed with phase I temporarily. There is no union of acetabular elements and even the acetabular margin has not begun to develop. The life period is clearly the first. The symphysis doubtfully involves the ischium.

A much older animal though still in the first life period is *Hylobates hoolock* B 159 (Fig. 30). In this the ridge and furrow system is very clear although the dorsal margin is beginning to grow quite vigorously. Neither extremity is even indicated and there is no ventral bevelling. The specimen must be assigned to phase II. The symphysial face involves the ischium to a small extent.

*Hylobates concolor* B 160 is a male in the early fourth period for the epiphysial lines of the vertebral centra are still visible. The two halves of the pelvis are united but quite recently for in the middle of the dorsal pubic area alone is there so complete fusion that the line of union cannot be made out. The entire absence of any ventral rampart or median disc can still be definitely asserted and as in the other specimens of *Hylobates* the ischium enters into the formation of the symphysis only at its extreme lowest part, and this is secondary as in the *Cercopithecidae*. The specimen belongs to phase VII.

*Hylobates concolor* B 161 (Fig. 32), is a female in the fourth life period in which there is complete fusion at the symphysis into which the ischium does not enter at all. The ischial rami approximate each other and are united by a fibrous band. One must assign this pubis to phase VII or later.

Our Gibbon records then, scanty as they are, fall more into line with the age relationships of the other Anthropoids than they do with those of the *Cercopithecidae*, although the symphysial face in its extent resembles the latter more closely.

In the graph are shown at a glance the age relationships of the various families and subfamilies of the Primates including Man (Fig. 45). The number examined, though considerable in the aggregate, is small when divided thus and doubtless many minor alterations would have to

be made if a much greater number were available. Leaving phase I out of account as being of less value and definition than the others the commencement of pubic metamorphosis occurs progressively earlier as we ascend the scale of the Primates until the Cercopithecidae are reached. This precocity is not long maintained and during phases IV, V, VI all the curves approach each other more closely. It is not yet clear as to why Man does not share in this early precocity.

The relationship of the Primate curve to that of other mammalian orders is laid out in the same figure.

#### THE RELATION OF ISCHIUM TO SYMPHYSIS

At several stages of the foregoing discussion the rôle played by the ischium in symphysis formation has come in for notice. At this point it is well to review the subject as a whole with the object of ascertaining the evidence relating to the evolution of this area in the Mammalia.

In Monotremes as in the mammal-like reptiles the symphysis consists in almost equal parts of pubis and ischium but so far as all other mammals are concerned there is a very different composition of the symphysis. The length of the symphysis in most Marsupials gives one the impression at first that the ischium enters largely into its formation. This is not the case; at most the ischium contributes merely the very lowest portion of the actual symphysis. The lower nodule (interpubic bone of Owen) by its fusion with the two sides of the ischial portions of the ischio-pubic rami gathers the ischia, as it were, into the symphyseal area. In some animals, *Petaurus* and the Kangaroos for example, the extent of the symphysis beyond the lowest level of the obturator foramina indicates considerable involvement of the ischia but as a rule the ischia do no more than lodge the lower nodule.

In the Rodents we have seen that certainly no more than this occurs and in most mammals the ischia take no part in the symphyseal formation even if it be long. Many Rodents have a rudimentary symphysis or none at all. In this order, as in the *Lipotyphla* among the *Insectivores* evolution is all towards reduction of the symphyseal length and eventually to its total elimination.

In the *Menotyphla* as represented by *Tupaia* the symphysis is coterminous with the limits of the pubic body and ramus; it does not infringe upon the ischia.

In the Carnivores there is an elongation which involves the ischia slightly, mainly as a result of their fusion with the lower nodule.

In the Ungulates the true symphysis is almost entirely confined to the body of the pubis. Involvement of most of the pubic and of the

ischial portions of the ramus is obviously secondary and due to approximation of the rami and binding of them together by the median bar of bone rather than to genuine co-ossification.

All other orders except the Primates may be passed over as giving no help because of reduction or elimination of the symphysis.

In the Primates so far as the Lemurs, the giant Anthropoids and Man are concerned the symphysis involves the body and part of the ramal portion of the pubis. In the Platyrrhinae there is apt to be a slight encroachment on the ischium but nothing like so pronounced as in the Cercopithecidae. In both subfamilies of Old World Monkeys although the true symphysis is entirely or almost entirely limited to the pubic body and the pubic rami may be actually little involved an approximation of the ischia is apt to occur with secondary union. In *Hylobates* also the elongation of the apparent symphysis takes place from secondary involvement of the ischia.

The sum total of this evidence is that so far as Marsupials and Placentals are concerned involvement of the ischium in the symphysis is slight. It occurs only in pelves in which fusion takes place at the symphysis and indeed in only a certain number of this type. The replacement by a single median chain of ossification centers of the original bilateral ossification centers for ventral margin and extremities of the symphyseal face is followed by fusion at the symphysis and is quite in accord with the reptilian ancestry. In some of these pelves, the Marsupials and Carnivores for example the symphysis only slightly involves the ischia. In the Ungulates involvement of the ischia is supernumerary and not due to real inclusion in the symphyseal area.

#### EVOLUTION OF THE EUTHERIAN SYMPHYSIS

The characters of the actual primitive mammalian symphysis can only be learned from fossil material but in much of this the symphyseal area is missing. Especially is this true of the vitally important specimens. Hence it will not be amiss to state what can be discerned from the study of recent skeletons. Two alternatives only can be supposed regarding the primitive Eutherian symphysis. One is that originally the symphysis was long and involved both pubis and ischium. The other is that the symphysis was very short and restricted to the pubis. There is no justification at all for the second view so far as Reptilia are concerned. The mammal-like reptiles of the Permian and Triassic all showed the plate-like symphyseal area characteristic of reptiles in general and still represented in existing Monotremata. Marsupials



(with the exception of the very specialized *Notoryctes*), most Carnivores, some Rodents and a few Insectivores display symphyses in which the ischium is involved but to no great extent. Indeed the involvement of the ischia is largely associated with the occurrence of a median ossification which we have named the lower nodule. In no other Eutheria does one find the complete ischio-pubic symphysis with all the factors which build up the symphyseal area. Even in these the pubic part is obviously the more important; it has a greater dorsoventral depth and the details of its formation and ultimate fusion differ from those of the ischial portion.

In the Ungulates which retain the long ischio-pubic symphysis the ischial portion has become supernumerary and presents a symphyseal face which is quite rudimentary and easily distinguished from the pubic part. The pubic symphyseal face, on the other hand, is large and becomes the chief bond of union between the two pelvic halves. In spite of reduction of the ischial symphysis the Ungulates retain the lower nodule and the long median bar although since these have lost their original intimate relation to the ischial symphyseal face, the bone formed by them unites with the symphyseal area comparatively late. This is understood at once when one recalls that the union takes place first in the lower (ischial) portion. Thus in young animals the ossified median bar with the lower nodule is apt to be lost in maceration.

In Rodents there is a well marked tendency to shortening of the symphysis. Even though the actual length of the symphysis be rather great it may be comprised in its entirety by the pubis. In this order are symphyses retaining the lower nodule as in *Castor* (Anderson, 2); symphyses in which the lower nodule ossifies from two distinct centers (*Dolichotis* B 267); symphyses in which the lower nodule does not exist as such but is replaced by a bilateral ossification, apparently the ventral extremity of the ischial tuber epiphysis (*Trichys* B 264). There are other types of symphysis limited to the pubis showing an ever greater shortness until one reaches the type of pelvis in which no symphysis occurs at all.

In the Insectivores and their allies the same varieties of symphysis are found, but not with the same gradual gradations, as occur in Rodents.

Edentates show an extremely short symphysis which nevertheless presents distinct indications that it once was more typically Eutherian.

In Primates there is developed a median bar but no lower nodule. The symphyseal faces are completed, as in *Trichys*, by extension of the epiphysis for the tuber. The upper nodule is irregular in many ways

and is always bilateral. The symphysis involves only the pubis except doubtfully in a few representatives of various Families (see pp. 393-394) the most notable instance being *Pan*. In the giant Anthropoids frequently and in Man always fusion of the two pelvic halves at the symphysis is lacking. Upper nodule, median bar and lower nodule are represented by bilateral ossifications in the adjacent soft parts along the ischio-pubic ramus.

The foregoing summary of facts already presented in the body of this paper indicates clearly that quite early in the history of the pre-mammals or the primitive mammals a marked differentiation occurred at the symphysis. Instead of the ischium and pubis playing equal parts in the symphysis the pubis became vastly more important for some reason regarding which we know nothing at present. Participation by the ischium, on the contrary, greatly dwindled until merely a fraction was left. This resulted in a separation of the ischia of opposite sides. Perhaps the lower nodule disappears. Perhaps its originally bilateral centers become separated and form the lower extremities of the symphyseal faces of the two sides. In favor of this is, first, the case of *Dolichotis* B 267, with its bilateral ossification of the lower nodule. Secondly many Primates, including Man, show a bilateral ossification completing the symphyseal face below.

Further stages in the evolution of the symphysis occur in the Primates. In many giant Anthropoids and in Man there is failure of the symphysis to unite at phase VII. On the contrary there is an obviously secondary union of ischia in *Cercopithecidae* and in *Hylobates* to some extent. This type differs absolutely from the condition in Ungulates in that there is no vestige of a lower median nodule. Continued shortening of the symphysis has taken place in Rodentia, Insectivora and Edentata, in other specialized orders and in specialized genera of more typical orders until ultimately the symphysis is absent altogether.

In the above manner it is a simple matter to trace out the history of the mammalian symphysis from the primitive and typical Eutherian form which engages the ischium to a small extent only and is still represented in Marsupialia, Carnivora, metotylous Insectivora and some Rodentia. The Ungulates which we have discussed show a symphysis plainly indicating its derivation from a primitive type with these features. The Primates must have early broken away from the typical Eutherian stock and developed a symphyseal area such as is exhibited by *Microcebus* B 434. From this can easily be derived a type like that of Man and some giant Anthropoids on the one hand, and

a type like that of the Cercopithecidae (e. g. *Pithecus nemestrinus* B 337) on the other. No other interpretation of the facts seems to me possible. It may be objected that one should not derive a bilateral structure from a median one. This is correct but as has been shown the median nature of the nodules and median bar is itself secondary. We are dealing with conditions in which this secondary median structure is now breaking up into its component parts. The relation of this to the human symphysis is reserved for part VI of the present memoir.

#### PRINCIPLES OF MAMMALIAN PUBIC METAMORPHOSIS

In the previous section have been noted the stages in specialization of the symphyseal area and a view of symphyseal evolution has been put forward. In the body of the memoir we have made frequent reference to successive phases of pubic metamorphosis and have observed that the phases as originally outlined for Man have been almost equally useful for mammals in general.

In the young mammal in the earlier part of the first life period the symphyseal face is a gently rounded bony surface with no definite margins and apparently continuous on to the ischial ramus. It is of subequal ventro-dorsal diameter throughout. The horizontal bony ridges and furrows are either not present or very slightly marked. A typical example is *Pithecus rhesus* Audebert B 150. Animals with rudimentary symphyses like *Galeopithecus* or *Gymnura* never develop any features of the surface characteristic of later phases. It is often difficult to distinguish between this infantile stage and the pubescent phase I, hence for present purposes of convenience such specimens are included as "Phase I or earlier."

Phase II presents the same general similarity to phase I as in Man and is an intermediate stage towards the more definite phase III which, while closely resembling that of Man presents certain additional or alternative features. The dorsal margin develops first in the upper part and is quickly followed by the appearance of a dorsal platform adjacent. Ventral to these features are the remnants of the horizontal ridges and furrows. The lower symphyseal face lingers behind the upper in differentiation and at the stage when the upper part exhibits the features just enumerated may still show the complete and unchanged ridges and furrows. Such a specimen is *Pithecus rhesus* B 460. Another feature is the late appearance of ventral bevelling. In Man we are accustomed to expect this in the third phase but in mammals generally it may not take place until shortly before the development of the ventral margin (median bar).



Phases IV and V show the same general characters as in Man and also show the same confusion. The upper extremity usually becomes defined second but may be indicated at the same time as or even before the lower. This confusion in Man caused me to hesitate for a long time before determining the phase relationships as I finally submitted them in my first paper (26). It is interesting to note that the same confusion occurs in other animals. I am inclined to consider this a secondary phenomenon, possibly retrogressive, the more primitive condition being that in which definition of the lower extremity distinctly precedes delimitation of the upper. In phase V ventral rarefaction can always be found although sometimes molecular in appearance.

Phase VI is the stage of development of the median bar in pelves in which there is a single median chain of ossification centers. This takes place by extension from the upper and lower nodules. Usually it becomes fused with the underlying ventral part of the symphyseal face almost at once and thus produces the ventral margin corresponding to the ventral rampart of some human symphyses. But in the Ungulates the median bar ossifies very early, probably at about phase III, and remains ununited until much later. There is correspondingly a complete absence of ventral bevelling until just before phase VI commences in these animals. It is difficult to say whether the metamorphosis typical of Ungulates is an exaggerated example of what I have called the sporadic attempt at ventral margin formation which is apt to occur during phase V in Man. The processes are undoubtedly the same but compared with most mammals this stage of metamorphosis is greatly retarded in Man whereas it is accelerated in Ungulates. One would hesitate therefore to compare the two processes at all closely. One may ask if any fusion of the two sides takes place during phase VI since the median bar rapidly unites with the underlying bone. It certainly does but through the medium of the median bar only. This fusion may take place before the median bar itself is completely formed. No fusion of the symphysis behind takes place during this phase.

Phase VII in Man is significant because it is during this phase that changes take place in the symphyseal face itself. The change which occurs must necessarily differ according to whether the symphyseal faces are going to fuse or to remain separate. If, as in Man, they remain separate the change is one of settling down into quiescence. If on the other hand fusion is to occur it will take place at this stage. This fact cannot be too strongly emphasized. Union of the two pelvic halves invariably occurs at this stage if the fusion is normal and not patho-

logical. Some animals are particularly appropriate for the study of this problem, notably the giant Anthropoids. In certain of these fusion does occur and our records show that union took place always at this particular stage. In others fusion does not occur and the symphyseal faces of these specimens have undergone changes which are typical also of Man.

Phases VIII and IX are indistinguishable in mammals whose symphyseal faces unite. They can be represented by the sign phase VII+

Phase X is as well marked in other mammals as it is in Man. It presents the same characteristics and is just as easily differentiated from phases VI and VII as in human bones.

It will be seen that there are no strikingly new features to be recorded for mammals generally beyond those already laid down for the investigation of the human symphysis. There is therefore no need for a separate tabulation of phases.

#### FATE OF THE MEDIAN BAR

Three distinct types of symphysis are to be found among the Eutheria.

1. Those in which the two pelvic halves ultimately (in phase VII) fuse together at the symphysis.
2. Those in which, as in Man, the two pelvic halves remain separate throughout life but articulate together by symphyseal bony surfaces.
3. Those in which the two pelvic halves do not meet at the symphysis but either are united with each other simply by a ligamentous band, the bony surfaces not touching, or are more or less widely separated and have no connection at all.

When one examines in detail the features of metamorphosis of these three groups certain significant differences emerge. The third type is plainly retrogressive. No accessory ossification centers occur in the area of these symphyses; the symphyseal faces, if they are present at all, are merely rounded cancellous masses of bone covered by the merest shell of compact tissue and without definite pattern or margins. An example in which symphyseal faces do occur, yet do not articulate is *Gymnura*. The Edentates possess symphyses which are apparently aberrant forms of the first type. Their symphyses must therefore be considered after the more usual ones.

The second type is found in Man and in some examples, but not all, of the giant Anthropoids. As a rule in these cases the symphyseal outline grows up by gradual accretion of bony substance; first the dorsal margin, next the lower extremity followed almost at once by the upper,

and last of all by the ventral margin. Further, the development of these margins takes place without apparent relation to any epiphysial ossification along the ischio-pubic ramus. It will be our aim in the succeeding section of this monograph (Part VI) to present evidence for the explanation of the evolution of this type of metamorphosis from a form in which bony development from epiphysial or secondary centers occurs along the ischio-pubic ramus up to and into the areas of the symphysis. These represent the median bar with its nodules as seen in other orders.

We now pass to the first type of symphysis, namely that in which fusion of the two sides takes place during Phase VII. Eliminating the aberrant symphyses of the Edentates, the Ungulates, the Cercopithecidae and Hylobates we find a short form and a long form. The former is represented by some examples of the giant Anthropoids among other mammals, and the latter by Carnivores and Marsupials. The distinction between these two is briefly summarized in the character of the lower symphysial extremity. In the giant Anthropoids cited the lower extremity forms as in the majority of human specimens by the gradual development of a definitive margin. In the long or typical Eutherian form it develops by the appearance of a single median mass of bone (the triangular ossicle of Owen) which fuses with the ischia and thus completes the symphysis below. At first these seem far removed from each other although no doubt, if the entire ossification could be examined in a fortunate series, the lower nodule (interpubic bone) would be found to ossify from a double center. The clue to the relationship of the two forms, the long and the short, is given by certain Rodents, for example *Dolichotis* B 267, and *Trichys* B 264 and by *Microcebus* B 434. In this specimen of *Microcebus* the independent bony centers for the formation of upper and lower extremities are clearly seen (Fig. 26) and there is no doubt that the condition of the giant Anthropoid represents this in retrogressive form. In *Dolichotis* (Fig. 12) the lower nodule is bilateral and composed of two separate ossification centers. The Rodent symphysis like that of *Microcebus* is precisely where, upon phylogenetic grounds, one would expect to find evidence in favor of bilateral origin if such evidence there be. We are fortunate in the possession of these pelvises which give the necessary data.

The evidence presented for the lower nodule may be applied to the elucidation of the median bar itself. To obtain direct evidence of the bilateral nature of this feature through a double ossification in symphyses where ultimate fusion takes place does not appear to be a profitable task. Yet the evidence for the lower nodule (or extremity)



combined with that for the upper extremity in *Microcebus* and for the ventral rampart in Man (see part VI later) indicates clearly the bilateral origin. One must infer therefore that the median bar with its associated expanded upper and lower nodules is a secondary though ancient phenomenon and that *Dolichotis* and *Microcebus* show a breaking down into the original elements. It also follows that the type of symphysis presented by Man is retrogressive and that the symphysis of the giant Anthropoids is likewise retrogressive though not to quite so advanced a degree.

In the Ungulates we have apparently a type of symphysis in which the union of the ischia is supernumerary and now more or less accidental through approximation. The condition is undoubtedly secondary and the union certainly seems almost hap-hazard in consequence of approximation. But there are features which clearly indicate the ancestral history of the present appearance. A distinct median bar occurs at least in the Artiodactyla, and although a bar is rudimentary or absent in the Perissodactyla both orders possess a definite lower nodule. This lower nodule or interpubic bone is a certain indication of a once typical Eutherian symphysis especially when accompanied by a median bar. Since the lower nodule in the Ungulates unites the ischia it follows that the symphysis at one time included the entire pubis, both body and ramus, and further extended to the ischium. More recently the true symphysis became confined to the pubic body with resultant specializations which have already been discussed. The part of the symphysis formed by the ischio-pubic rami dwindled in importance and became rudimentary, but the lower nodule maintained its original position. We conclude therefore that the Ungulate symphysis passed through a typical Eutherian stage.

Far different is the symphysis of the Ceropithecidae and of Hylobates, although here again we have the union of pubic and to a small extent of ischial rami. The final result is not unlike that in Ungulates, but the two types are widely different in their history. There is no lower nodule in relation to the ischia of these animals. There is no lower nodule at all but its bilateral representative, if it occur, is found forming the lower extremity of the true symphysial face on the body or at lowest on the ramus of the pubis as in *Microcebus*. The union of the greater part of the pubic rami and also of the ischial rami, if these be united, is certainly a secondary one through approximation and obtains at a lower level than the site of the representative of the lower nodule or interpubic bone. There must be no confusion between this type and

that of the Ungulates. The Cercopitheque symphysis has developed after the Primate symphysis became fixed. It is not a direct derivative of the typical Eutherian symphysis.

Finally concerning the Edentates it must be pointed out that since they present a lower nodule even in their short symphysis, they must have passed through a stage corresponding to the first type of symphysis where, in association with length of the symphysis and development of a median bar the lower nodule has been formed. As the symphysis became shorter in retrogression the lower nodule remained as the earmark of the former condition. Judging the Lipotyphla in light of the Menotyphla these also must have passed through the general Eutherian stage represented by type 1, but they have become vastly more specialized than the Edentata in this regard. Rodents with an extremely short or missing symphysis fall into the same category.

#### THE INFLUENCE OF AGE UPON EXTENT OF THE SYMPHYSIS

In the last chapter we have observed that the Primate symphysis early diverged from the typical Eutherian stage. We have also noted that the Cercopitheque extension, by which the ischium is involved in the symphysis, is a quite late modification after the Primate type of symphysis became fixed. It is instructive to inquire into this peculiar extension. I have therefore arranged in tabular form information regarding extent of the symphysial area in relation to successive life periods. In this manner one may see at a glance the bearing of age.

Genus.	Sex. Number.	LIFE PERIOD.					
		1	2	3	4	5	6
		LEMUROIDEA					
Microcebus	M. B 434		Body				
Nycticebus	M. B 136		Body				
Tarsius	?. B 135				Body		
Lemur	?. B 138		Body				
Lemur	F. B 197				Ramus sl.		
Lemur	F. B 344				Ramus sl.		
Lepidolemur	M. B 345				? Ramus sl.		
Lemur	M. B 137				? Ramus sl.		
Indris	M. B 343				Ischium		
Daubentonia	M. B 198				Ramus		

Genus.	Sex.	Number.	LIFE PERIOD.					
			1	2	3	4	5	6
CEBIDAE.								
Ateleus	M.	B 141		Ramus				
Cebus	M.	B 142		Ramus sl.				
Aotus	F.	B 342		? Isch.				
Alouatta	M.	B 340			Ramus sl.			
Cebus	?	B 146			Ramus sl.			
Saimiri	F.	B 341			Body			
CERCOPITHECIDAE.								
Pithecus	?	B 150	Ramus					
Pithecus	F.	B 460	Body					
Pithecus	?	B 148	Ramus					
Pithecus	M.	B 337			Isch.			
Lasiopyga	M.	B 147			Isch.			
Papio	M?	B 151			Isch.			
Pygathrix	F.	B 158		Isch.				
Pygathrix	F.	B 622			Isch.			
ANTHROPOIDEA.								
Hylobates	?	B 162	? Isch.					
Hylobates	M.	B 159	Isch.					
Hylobates	M.	B 160				Isch.		
Hylobates	F.	B 161				Ramus		
Pongo	?	B 164	Ramus					
Pongo	?	B 625	Ramus					
Pongo	M.	B 623				Ramus		
Pongo	M.	B 172				Ramus		
Pan	?	B 168	? Ramus					
Gorilla	?	B 169	? Ramus					
Pan	F?	B 347	? Isch.					
Pan	F?	B 346	? Isch.					
Pan	M.	B 540	Isch.					
Pan	F?	B 461	Isch.					
Pan	F.	B 459		Isch.				
Pan	F.	B 458		Isch.				
Gorilla	F.	B 626			Ramus sl.			
Gorilla	M.	B 624			Ramus			
Pan	M?	B 543				Ramus		
Gorilla	F.	B 239				Ramus		
Pan	M.	B 629				Ramus		
Gorilla	F.	B 627				Ramus		
Pan	M.	B 630				Ramus		
Pan	M.	B 628				Ramus		
Pan	F.	B 171						Ramus sl.



In the foregoing table contractions are used as follows:

*Body* means that the symphysis is confined to the pubic body;

*Ramus* means that the symphysis extends on to the pubic ramus;

*sl.* means slightly;

*Isch.* means extension of symphysis on to ischium.

The table shows several significant facts.

In the Lemurs the symphysis is practically limited to the pubic body except in *Indris* and *Daubentonias*. The loss of the tail and the habits of *Indris* may have some important relation to this unusual condition. *Daubentonias* in many ways is closely related to the *Indrisinae* and perhaps this accounts for the extension which involves much more of the pubic ramus than in other Lemurs, although, as previously stated the symphyseal area seems to have no definite taxonomic value.

In the New World Monkeys extension of the symphysis to the pubic ramus has become fairly fixed, but it is only slight.

In the Old World Monkeys and Apes extension to the pubic ramus occurs quite early in life. Somewhat later the ischia also participate in the symphysis. The obviously secondary nature of this involvement is clearly shown in Fig. 27 which is a photograph of *Pithecus nemestrinus* B 337. With involvement of the ischia there seems to develop a curvature of the symphyseal area with ventral convexity. It really appears as if this is an extension occurring between the first and second life periods in these animals. If this is ultimately proved to be the case it will be an astonishing acquired character since in *Hylobates* it occurs much earlier.

*Hylobates* represents the maximum Primate involvement of ischium.

Again in *Pan* there is undoubted ischial involvement in some but not in all instances. It is much less than in *Hylobates*. Sex has no relation to this extension so far as our examples go.

In *Gorilla* and *Pongo* the symphysis does not involve the ischium.

In general one must admit that there is some evidence of extension of the symphysis in various Primates during life, and that this extension takes place somewhere about the beginning of the second life period. The evidence is the following.

In the *Cercopithecidae* specimens show definitely a limitation of the true symphysis to the pubic body (though it may slightly encroach upon the pubic ramus). This symphyseal face is oval with the long axis vertical and is distinctly marked off from the secondary symphysis resulting from approximation as illustrated in *Pithecus nemestrinus* B 337 (Fig. 27). The appearance of this specimen is quite typical of

the others. Further, in young specimens there is no indication of the secondary symphysis but there is evidence of the presence of an ischio-pubic epiphysis in the extension of transverse ridges along the ischio-pubic ramus for an indefinite distance (e. g. *Pithecus rhesus* B 460 see p. 376). This epiphysial surface could not be mistaken for the symphysial face because it is much narrower and between the two is a pretty definite demarcation. The third piece of evidence is the occurrence of this same epiphysial marking in *Pan* (see Fig. 37) in some specimens of which symphysial involvement of the ischium takes place. My belief is that involvement of the ischium in *Pan* is brought about by extension of the symphysial face to include a part of this epiphysial mass. There does not seem to be the actual bending which occurs in the Cercopithecidae.

Looking over the table one might imagine that the Lemurs also confirm this view but this is not so. The younger specimens almost all belong to a group which presents a typically short symphysis.

If then age has any bearing upon the length of the symphysis it is shown only in the Cercopithecidae and to a less extent in *Hylobates* and *Pan*. I have seen no evidence in any other mammals.

#### RELATION OF SEX TO THE MAMMALIAN SYMPHYSIS

There is a general impression, applying to Man as well as to other mammals, that sex bears a rather constant relation to the form of the symphysial face. It is said that the long symphysis is characteristic of the male, the short characteristic of the female. The problem, so far as it affects the form of the human symphysis has not yet been touched upon in the present work but one could not leave this section of the memoir without referring to the sex question both as regards form and metamorphosis.

As to metamorphosis a vastly greater amount of material would be necessary to justify any conclusions whatever. Unless greater sexual difference were to occur than is present in Man, and on general grounds this is certainly not to be expected, we should require almost as many skeletons of known age and of one mammalian family at least as were used in the survey of human material, before a definite statement could be made. In the present investigation I have found nothing which would even indicate a sexual difference in mammalian pubic metamorphosis.

We pass then to the consideration of form. In the Ungulates it has been pointed out that there is a very definite sexual distinction in shape of the symphysial face; this is even more pronounced in the Perisso-

dactyla than in the Artiodactyla. I am not able to speak regarding other Ungulate orders. In the male the symphyseal face is biconvex; in the female, owing to flattening of the pelvic aspect of the symphyseal area, the symphyseal face is almost plano-convex, the convexity being directed ventrally. In the Mare the symphyseal face is even concavo-convex. The distinction between the sexes is shown by a comparison of Figs. 13 and 14 which illustrate the symphyseal face in *Odocoileus virginianus*.

Nowhere else among mammals does one find this clear distinction nor does the symphyseal face itself by its pattern indicate sex in any mammalian order. There is one feature which often indicates sex though not very strongly. When discussing the position of the pubic tubercle in relation to sex in Man (26) I pointed out that the most characteristic sex feature in this part of the bone is neither the prominence nor degree of isolation of the tubercle from the symphysis but rather the massiveness of the upper border of the pubic bone. In other mammals, as in Man, this feature again stands out. It is not very well marked and even in the Anthropoids it may be quite equivocal. It is present in greater degree in Ungulates, and this fact gives a clue to its significance. In all mammals except Ungulates the symphyseal face is long and comparatively narrow. In Man it may be equally narrow and is usually not broad. In Ungulates on the other hand the symphyseal face is short and is confined to the upper part of the pubic body. The great dorso-ventral depth of the pubis in the male Ungulate is naturally reflected therefore in the massive upper pubic margin. The greatly reduced dorso-ventral depth in the female is likewise reflected in the sharp, or at least narrow, upper pubic margin. We have seen that the sexual difference is better marked in the symphyseal face of *Equus* than in any other of our Ungulates. It is therefore not surprising that we find the greatest sex difference in the upper pubic margin of this animal also. In Man this sex distinction is not invariable; often it is quite equivocal. One must expect this since the symphyseal face varies so much in dorso-ventral depth, and quite without relation to sex.

The actual or relative length of the symphyseal face alone remains for discussion. At a later date the results for Man will be presented. The actual length must of course be checked up against the individual as a whole and the relative length against some pelvic standard. Neither method meets so far with any measure of success. But if there is difficulty in judging of the relation to sex in the symphyseal length in Man



the difficulty is greatly enhanced in other mammals. It is true that V. D. Broek has, in 1911, depicted sexual differences in the symphyseal length of various Primates (3). The statements and the figures do not take into account the age or size of the animals and the photographs are not clear enough to enable me to draw any conclusions as to these points. There being no standard used for estimating the proportional length of the symphysis, and in the absence of sufficient data regarding the skeletons themselves it is impossible to use the work in the present investigation. I have seen no real evidence to justify belief in a sexual factor in symphyseal length. So far as the Primates are concerned the table on pp. 393-394 shows that even involvement of the ischium, which surely would bring about the most striking difference in symphyseal length, bears no definite relation to sex. An "appreciation" of sex founded upon symphyseal length is mere guess work.

#### GRAPHIC REPRESENTATION OF AGE RELATIONSHIPS

The mass of information contained in the body of this paper relating to pubic metamorphosis and life periods must be reduced to simple form before the salient facts become obvious. We have noted that no new statement of phases has been rendered necessary through the study of the Mammalia. The phases as arranged for Man are equally exemplified by other mammals. Two features however have to be kept in mind. In the Monotremes there are no epiphyses on the centra of presacral vertebrae and hence phase III drops out of consideration. Further, in most mammals which possess a fairly typical Eutherian symphysis, the two pelvic halves fuse in the midventral line. I have produced evidence that this fusion always takes place in phase VII or at the extreme end of phase VI. Without this clear understanding one would have difficulty in placing many of these pelves as regards phase.

With these facts in mind I have gone over in detail all the skeletons mentioned in this paper and have plotted out on millimeter paper each skeleton as regards the phase of its pubic metamorphosis and its position in the appropriate life period. Using smoothed graphs I have reduced them all to the single graph shown in Fig. 45 which well repays a little careful study. Although I have warned against the assumption that life period limitations necessarily occur at the same stages relative to either the total life span or any type of activity of the animal, yet since we are comparing all results with those obtained in the study of Man I have arranged the life period limits at intervals corresponding to those

found in Man. This I believe to be justifiable in the circumstances and in any case there is no other standard at present available.

The graph, in brief, shows that probably all mammals with the exception of Man commence to show active pubic metamorphosis during the first life period; that the Marsupials (and the Monotremes) complete their pubic metamorphosis, at least to phase VII, before the end of the second period; that they are followed a little later by the Rodents and by the very atypical Ungulates; that the Carnivores and the Primates pursue a very similar course and their curves practically parallel each other throughout the metamorphosis; and finally that Man lags behind in its commencement and during phases VII, VIII and IX. We must examine these points more closely.

Why the Marsupials should so greatly precede the other orders in completion of their pubic metamorphosis finds no explanation here. It is noteworthy that the Monotremes also complete metamorphosis very early. The Edentates reach phase VII before or early in the third life period. They are not quite comparable with the Marsupials for their metamorphosis starts late and progresses rapidly. It is more probably correct to interpret this phenomenon as related to the aberrant and very short symphysis. Among the Marsupials our three specimens of *Phascolomys* show some retardation in speed of metamorphosis.

Rodents, as one would expect from the very various character of their symphyses, show the greatest number of deviations from the precise line of the curve. *Trichys* is accelerated and *Mus* (but not *Hydromys*) is retarded.

The aberrant Ungulates pursue a course of their own and among them *Capra* shows some retardation. The specialization of the symphysial face in these animals renders absolute identification of the early phases very difficult.

Regarding the Carnivores there is no special comment to make. They are remarkably harmonious in their age relationship.

In the Primates the difference between the curves of the various groups may be more apparent than real. They may be partly due to the comparatively small number examined. The close connection between curves for *Cercopithecidae* and *Anthropoidea* is interesting. If anything Man falls nearer the Lemurs in this graph but I am not inclined to place much weight upon this.

The black dots represent anomalies among Primates. It is significant that these always show acceleration and that they all fall within the range of the Eutheria and not outside it. Regarding the human anoma-

lies we shall have more to say in part VI. The black circles simply indicate the sites of the commoner time anomalies.

#### NATURE OF THE ANTHROPOID SYMPHYSIS

The striking feature of the giant Anthropoid symphysis is that it may complete its metamorphosis by one of two methods. In one the metamorphosis is very similar to that found in the majority of human pelvises. The phases are the same of course but in addition there are the irregularity in time of definition of the upper extremity, the building up of the ventral margin by gradual accretion and without any sign of a ventral rampart, the development of a "rim" indicating phase IX, and the occurrence of senile changes of an identical kind. Since no other mammal presents features so similar in detail we may take it that the method of evolution of the human symphysis and this type of Anthropoid symphysis must have been the same.

The second type of symphysis brings the giant Anthropoid into relation with other Primates. In it there is formed a median bar ventral in position and expanded above but tapering below. By means of this first but later directly the two pelvic halves become fused in phase VII. In some way the presence of this median bar is related to the fusion which never takes place in any specimen not developing a median bar. I have already claimed that the original ossification must have been bilateral and that the median bar and indeed the fusion must be secondary though ancient features. Nevertheless the second type of Anthropoid symphysis is more primitive than the first; it is the result of an effort to follow the typical Eutherian course, and it failed because in no circumstances can a single median lower nodule be developed. It indicates why the ischial union of the Cercopithecidae is so certainly secondary.

But if the second type of symphysis is a specialization from the typical Eutherian form, the first, in its present form, is equally certainly a retrogressive condition. No indication of epiphysial formation is visible in it at all.

The relation of age and sex to form in the Anthropoid symphysis has been discussed in previous chapters.

The striking difference between the symphysial area in *Hylobates* and that of other Anthropoids is sufficiently evident. The symphysis of *Hylobates* is really an intensified form of Old World Ape symphysis. This simply confirms the position of *Hylobates* as ascertained by many other and much more important morphological features.



## NATURE OF THE BONY METAMORPHOSIS AT THE MAMMALIAN SYMPHYSIS PUBIS

Throughout this work the relationship of the symphyseal changes to an epiphyseal formation has been alluded to and commented upon, so that, although the final and complete demonstration must be left to part VI, it is advisable to recall briefly the points to which allusion has been made from time to time.

The symphyseal face itself resembles the diaphyseal side of a diaphyso-epiphyseal plane in the earlier phases of metamorphosis. The loss of this appearance with its billowy ridges commences behind. As the ossification of the soft tissue ventrally proceeds and forms successively the lower extremity or nodule, the upper extremity or nodule, and the ventral rampart or median bar, which are all quite obviously of an epiphyseal nature, the ventral part of the symphyseal face changes in its structure preliminary to ultimate fusion with these epiphyseal formations. In the Marsupial the median bar is an actual disc penetrating the tissues between the symphyseal faces almost as far as their dorsal limit. This is the fused "epiphysis" at its greatest development.

The irregularity in occurrence, in time of appearance, and in size and shape of the upper bony nodule indicate its condition to be that of a retrogressive epiphysis. Sometimes in Man it extends as far as the pubic tubercle but most often not.

The relation of the lower extremity or of the lower nodule to the epiphysis of the ischial tuber has been often commented upon and this clearly indicates its condition.

The methods of formation of the ventral margin, ventral rampart and ventral or median bar plainly illustrate the relation of this feature to an epiphysis more or less modified.

There is a tendency to failure of completion of the ventral margin, rampart or bar and of the upper extremity or nodule. This tendency is common in all Primates and Carnivores and even occurs sometimes in Ungulates. Its occurrence has been noted in Man. This common tendency is none other than a failure of ossification in a retrogressive epiphysis.

Altogether these features make plain the relation of symphyseal bony metamorphosis to a modified epiphysis.

Two other features common to the symphyses closely related on the graph (Fig. 45), namely the Carnivores, Primates and Man are first; the fact of fusion (excluding Man) taking place invariably at the same period, and secondly the similarity in type and position of secondary or senile changes. These invariably occur first either at the upper part

of the ventral margin or on the dorsal part of the symphyseal face. Ultimately the process extends over both areas (see Figs. 19, 25, 42).

#### SUMMARY

1. This paper forms a portion of a memoir upon the anatomy of the symphyseal region of the os pubis.

2. The evolution of the symphyseal area in Eutherian mammals is studied. It is shown that the Eutherian symphysis diverged early from the reptilian form illustrated by the Permian mammal-like reptiles and retained in existing Monotremes. The central feature of this divergence was the emphasis of the pubic portion of the symphysis with a correlated diminution of the ischial part. In certain forms, of which Man is one, the primitively fused symphysis is resolved again into two non-uniting components. Further changes go on in more specialized symphyses until no symphysis remains.

3. The Primate symphysis seems to have diverged relatively early from the typical Eutherian form.

4. In spite of very marked differences in type of symphysis there is observed throughout the Mammalia a definite and orderly type of symphyseal metamorphosis which corresponds in its broad features with that already described for Man.

5. Certain easily distinguished subdivisions of the life span are common to all Eutheria, and by the use of these it is found that the age relationships of the various phases of symphyseal metamorphosis can be indicated.

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28. Todd (T. W.)—1921. Age Changes in the Pubic Bone; II, III, IV. *Am. J. Phys. Anthropol.*, IV, 1-69.

## PLATE I.

FIG. 1. *Ornithorhynchus anatinus* B 174. Twice nat. size. Note reptilian plate-like pelvis; subequal participation of both ischium and pubis in the symphysis; absence of any ossification representing the median bar; small epiphysis ossified but not yet united on ischial tuber.



- FIG. 2. *Echidna aculeata* B 175. Nat. size. Complete ossification at the symphysis has taken place; a well-marked median crest is formed. This specimen and the last are in second life period.
- FIG. 3. *Petaurus breviceps* B 187. Four times nat. size. Note median bar expanding above and below into nodules.
- FIG. 4. *Phascolomys tasmaniensis* B 601. Nat. size. Note commencing ossification of lower nodule.

## PLATE II.

- FIG. 5. *Dendrolagus inustus* B 193. One half nat. size. The median disc penetrates backward between the symphyseal faces. The median bar is simply its ventral and most constant part. Through the lower nodule it connects with the epiphysis for the ischial tuber.
- FIG. 6. *Petrogale xanthopus* B 192. Three quarters nat. size. The ossification for the lower nodule is plainly seen; that for the upper nodule can only be seen from behind.
- FIG. 7. *Macropus bennetti* B 181. Note upper nodule with tongue of median disc extending downwards from it between the fusing symphyseal faces.
- FIG. 8. *Phascolomys latifrons* B 602. Nat. size. Complete fusion of pelvis at symphysis.
- FIG. 9. *Tupaia tana* B 211. Twice nat. size. Compare the median bar with that in *Petaurus* Fig. 3.
- FIG. 10. *Areomys monax* B 127. Twice nat. size. Outer aspect of left side; deep aspect of right side. Note that the symphyseal face is entirely upon pubis.

## PLATE III.

- FIG. 11. *Trichys guentheri* B 264. Five times nat. size. Note the completion of symphyseal face by epiphyseal continuation: no vestige of lower nodule. Beveling of ventral margin preparatory to building of median bar.
- FIG. 12. *Dolichotis patagonica* B 267. One and a half times nat. size. Note completion of symphyseal face in "epiphyseal" manner as in *Trichys*.

## PLATE IV.

- FIG. 13. *Odocoileus virginianus* B 634. Nat. size. Female. Note typical female appearance of symphyseal face.
- FIG. 14. *Odocoileus virginianus* B 649. Nat. size. Male. Note typical male appearance of symphyseal face.
- FIG. 15. *Muntiacus muntjac vaginalis* B 607. One half nat. size. Male. Note lower nodule as seen from behind.
- FIG. 16. *Odocoileus virginianus* B 633. One half nat. size. Female. Note median bar (pencil) continuous below through lower nodule with epiphysis of ischium. Upper nodule does not develop.
- FIG. 17. *Felis tigris* B 611. One half nat. size. Female. Note formation of ventral bar.
- FIG. 18. *Felis leo* B 334. Female. Nat. size. Note ischio-pubic symphyseal face.
- FIG. 19. *Felis leo* B 173. Female. One half nat. size. Note secondary changes following upon "rim" formation in uncompleted upper extremity. Distinguish carefully from B 611, Fig. 17.

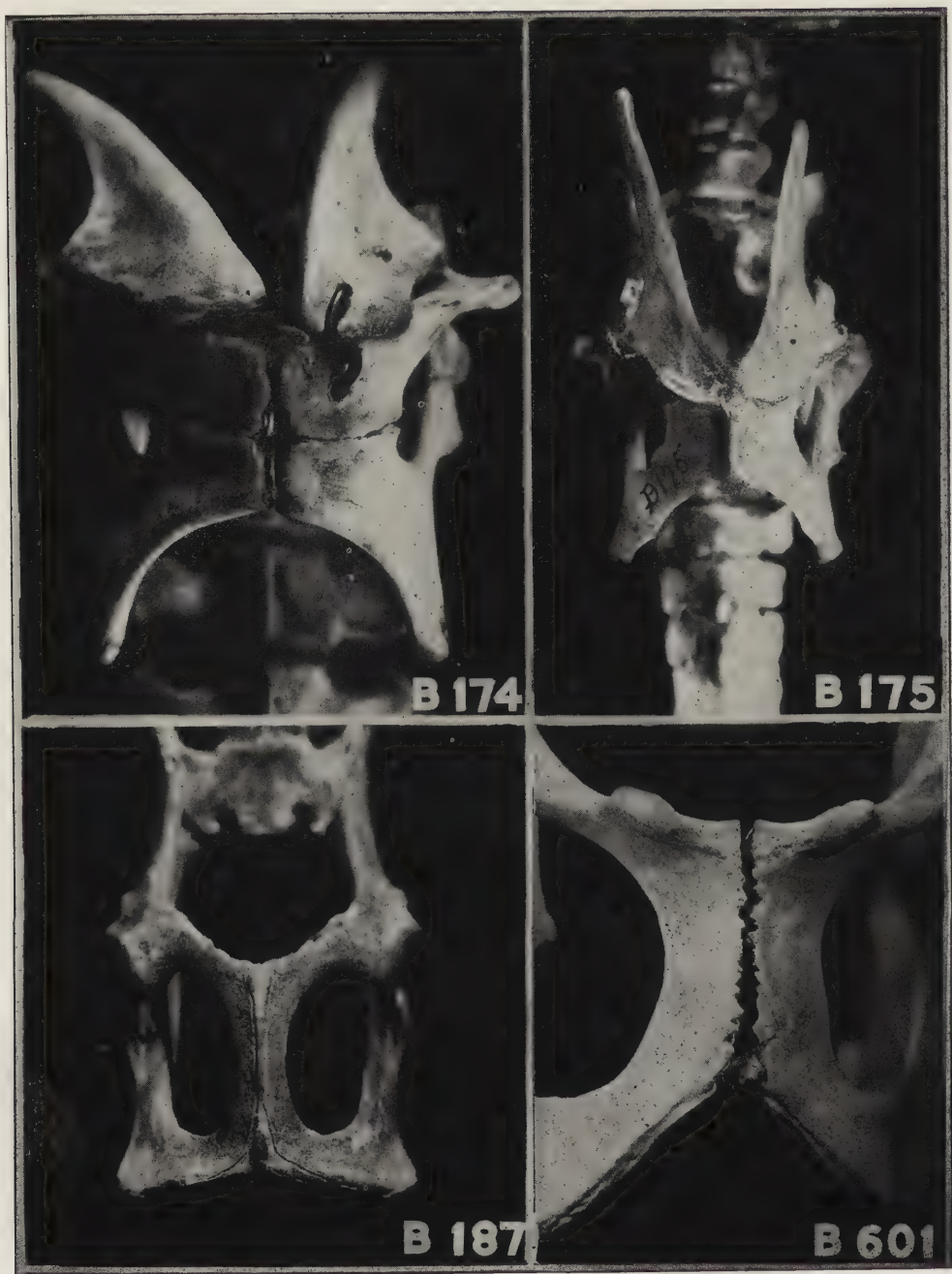


PLATE I  
Upper row, Figs. 1, 2.  
Lower row, Figs. 3, 4.

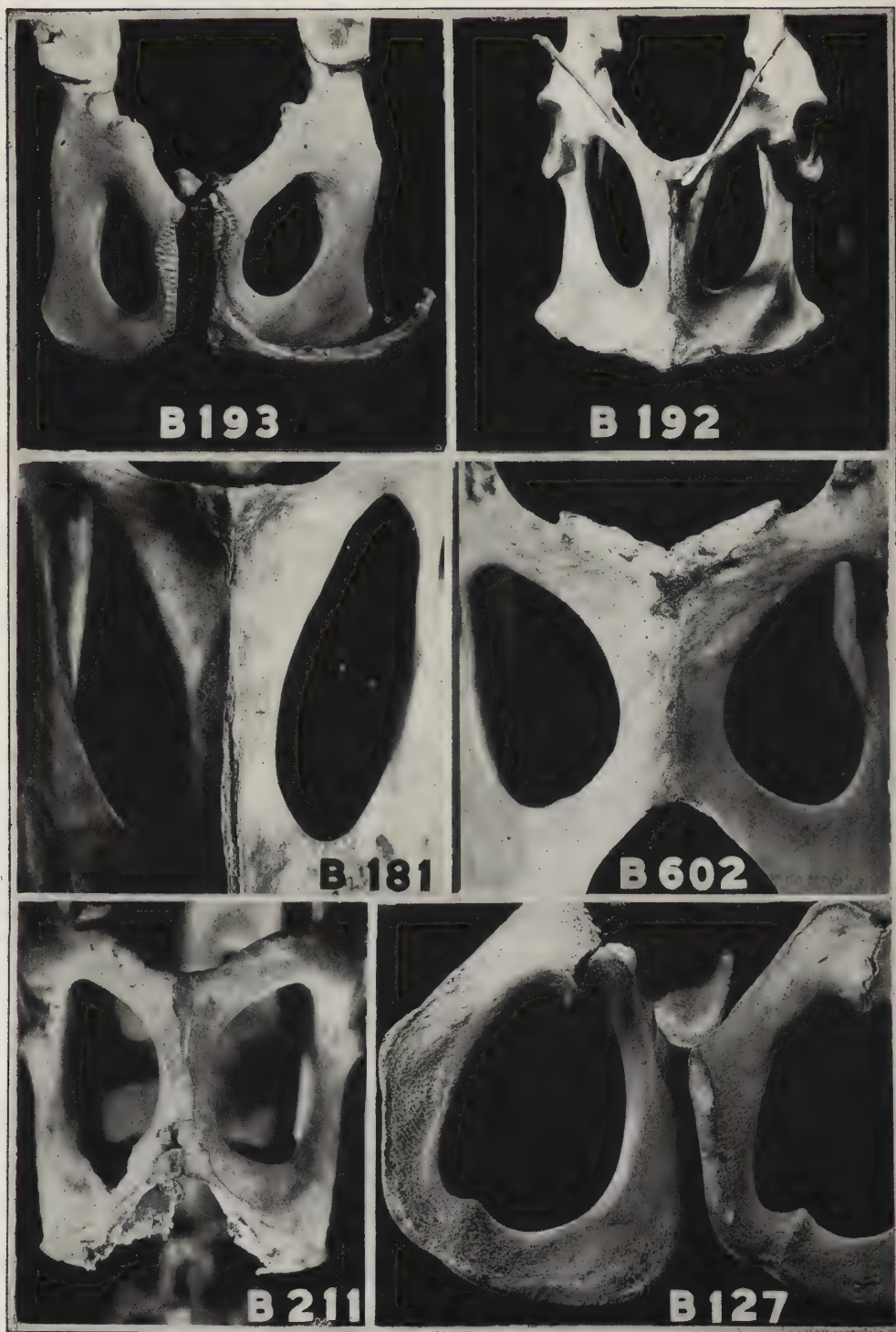


PLATE II

Top row, Figs. 5, 6.

Middle row, Figs. 7, 8.

Lowest row, Figs. 9, 10.



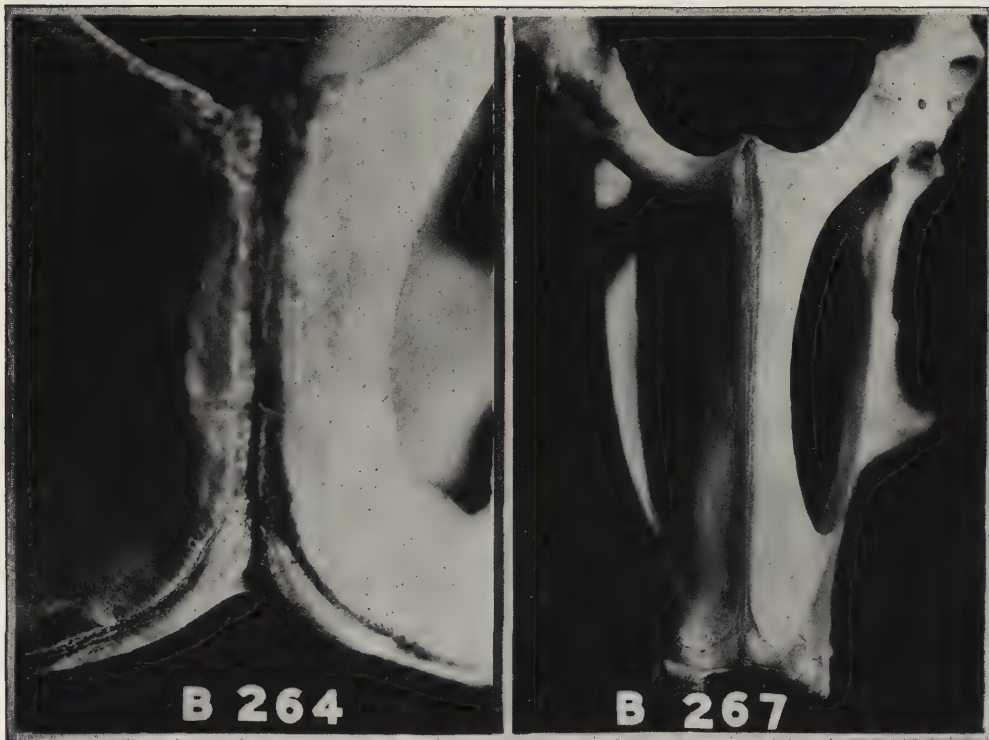


PLATE III

Figs. 11 (left), 12 (right).

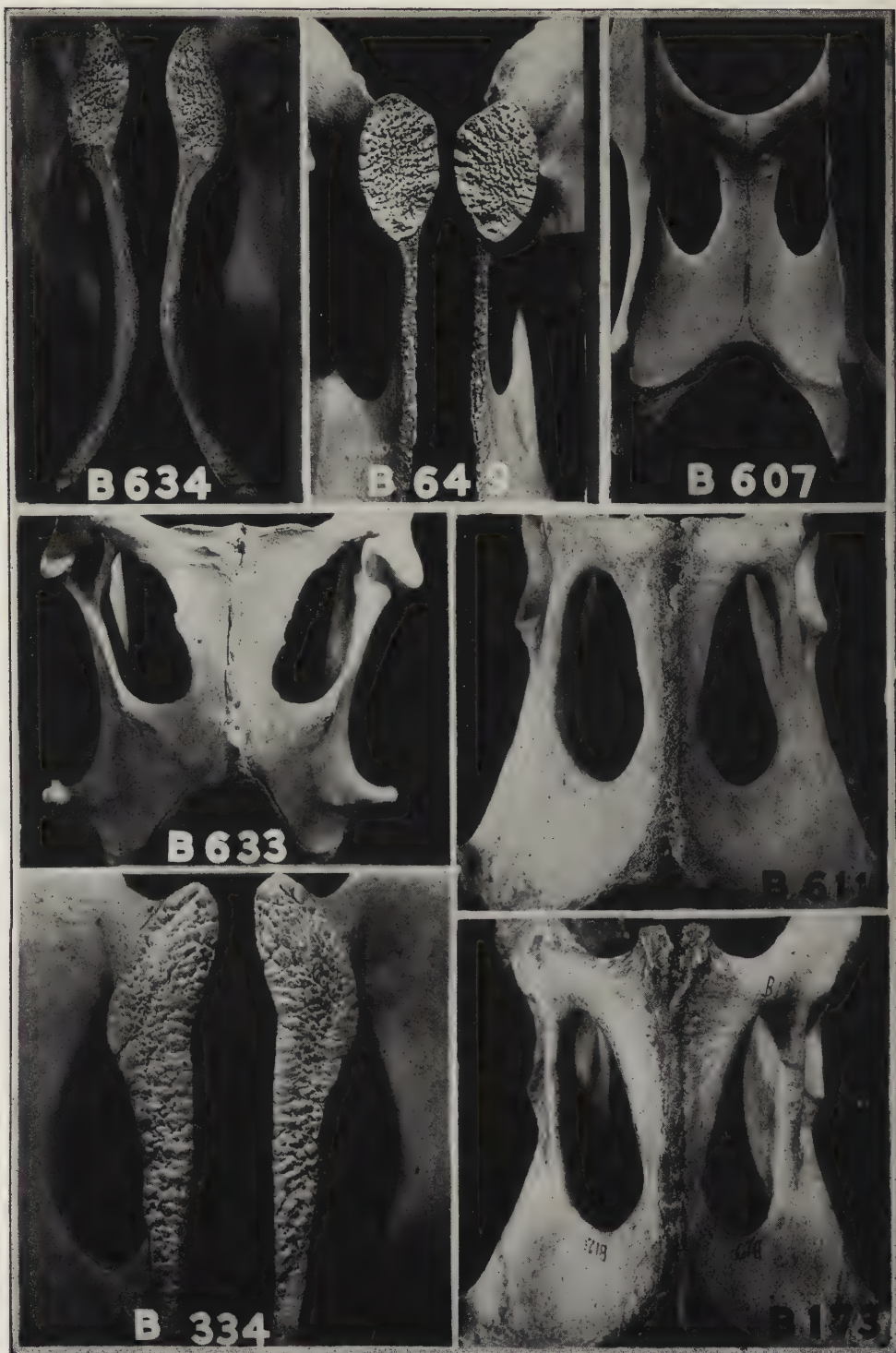


PLATE IV

Top row, Figs. 13, 14, 15.

Middle row, Figs. 16, 17.

Lowest row, Figs. 18, 19.

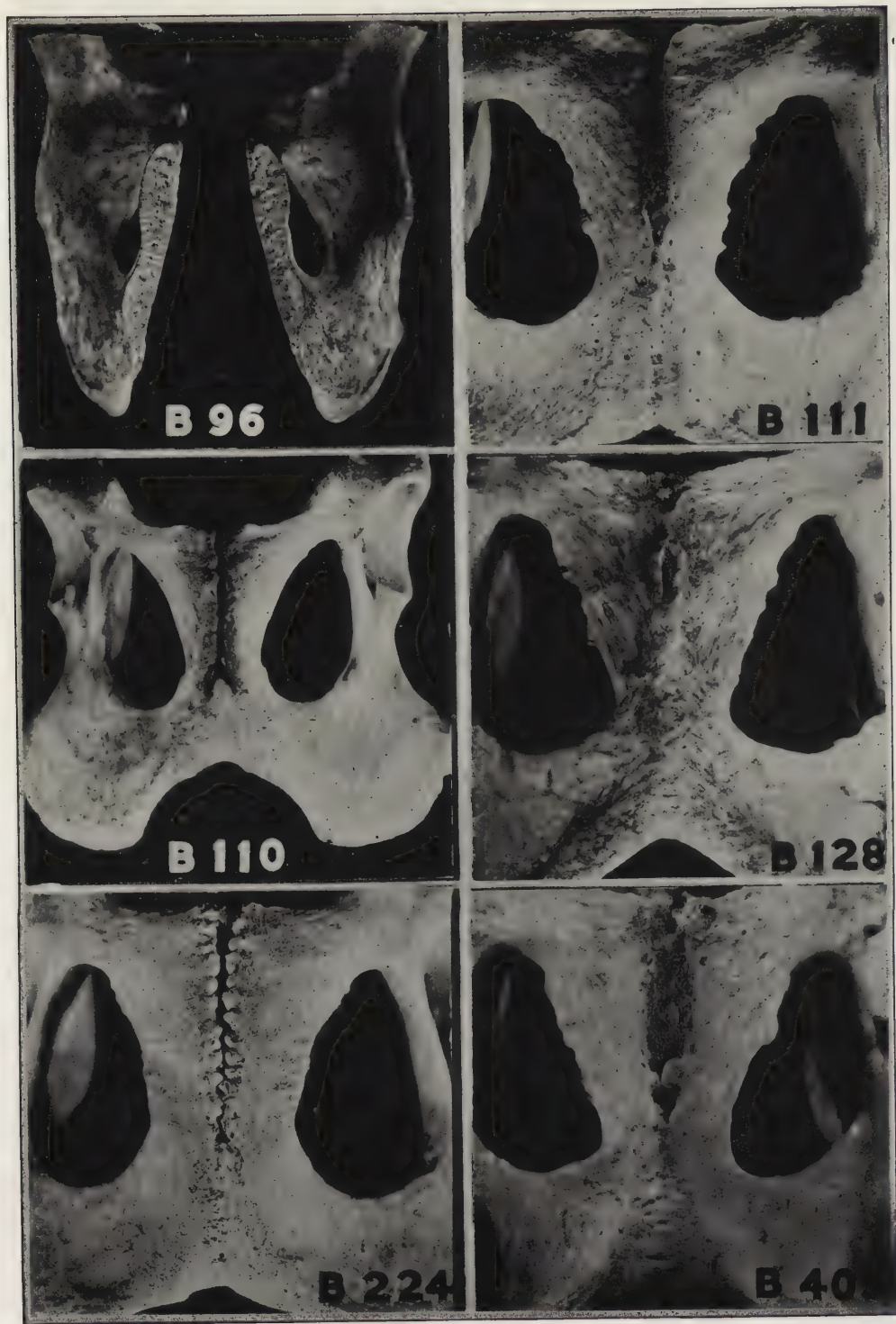


PLATE V

Top row, Figs. 20, 21.  
 Middle row, Figs. 22, 23.  
 Lowest row, Figs. 24, 25.



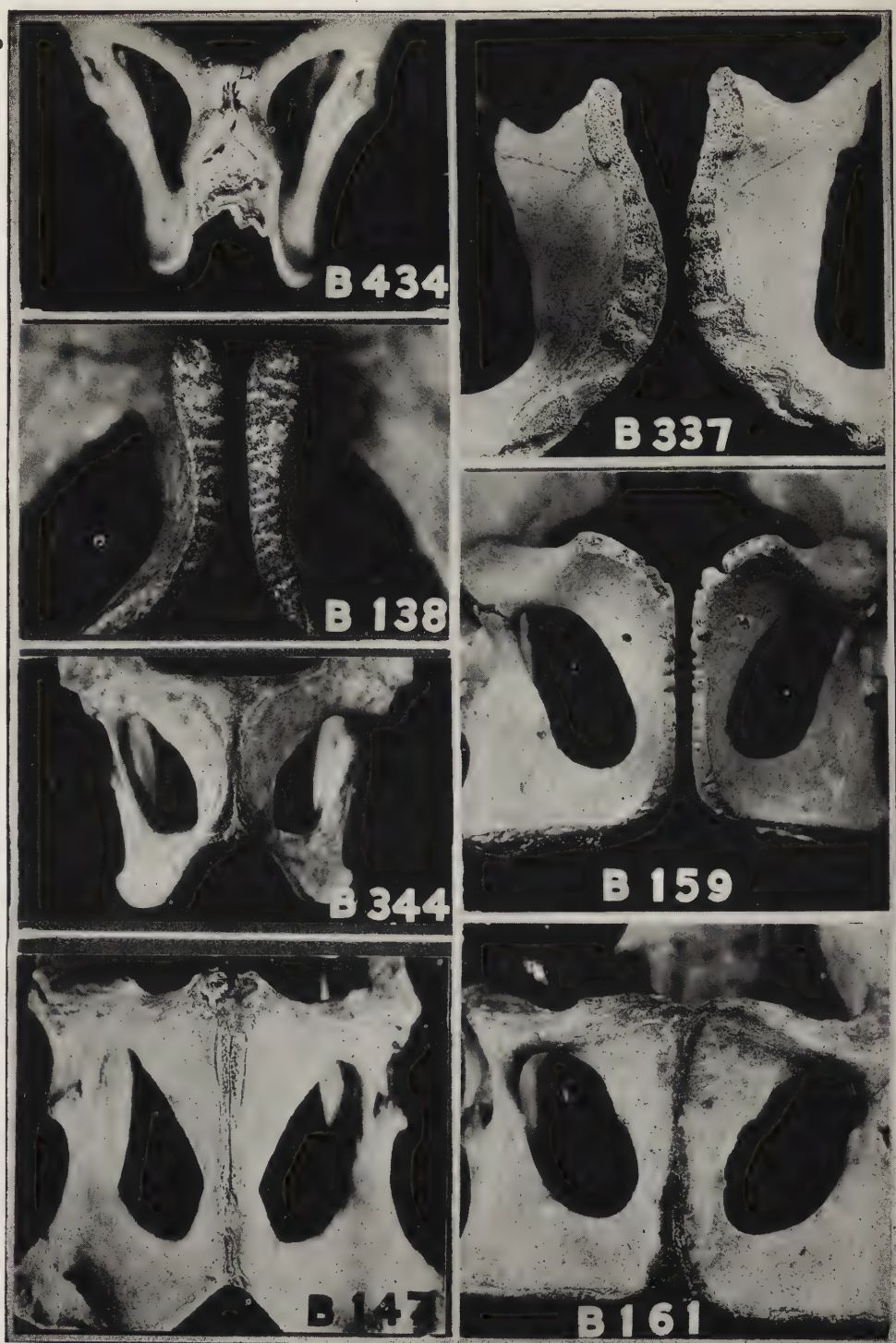


PLATE VI

Uppermost row, Figs. 26, 27.

Second row, Fig. 28.

Third row, Figs. 29, 30.

Lowest row, Figs. 31, 32.

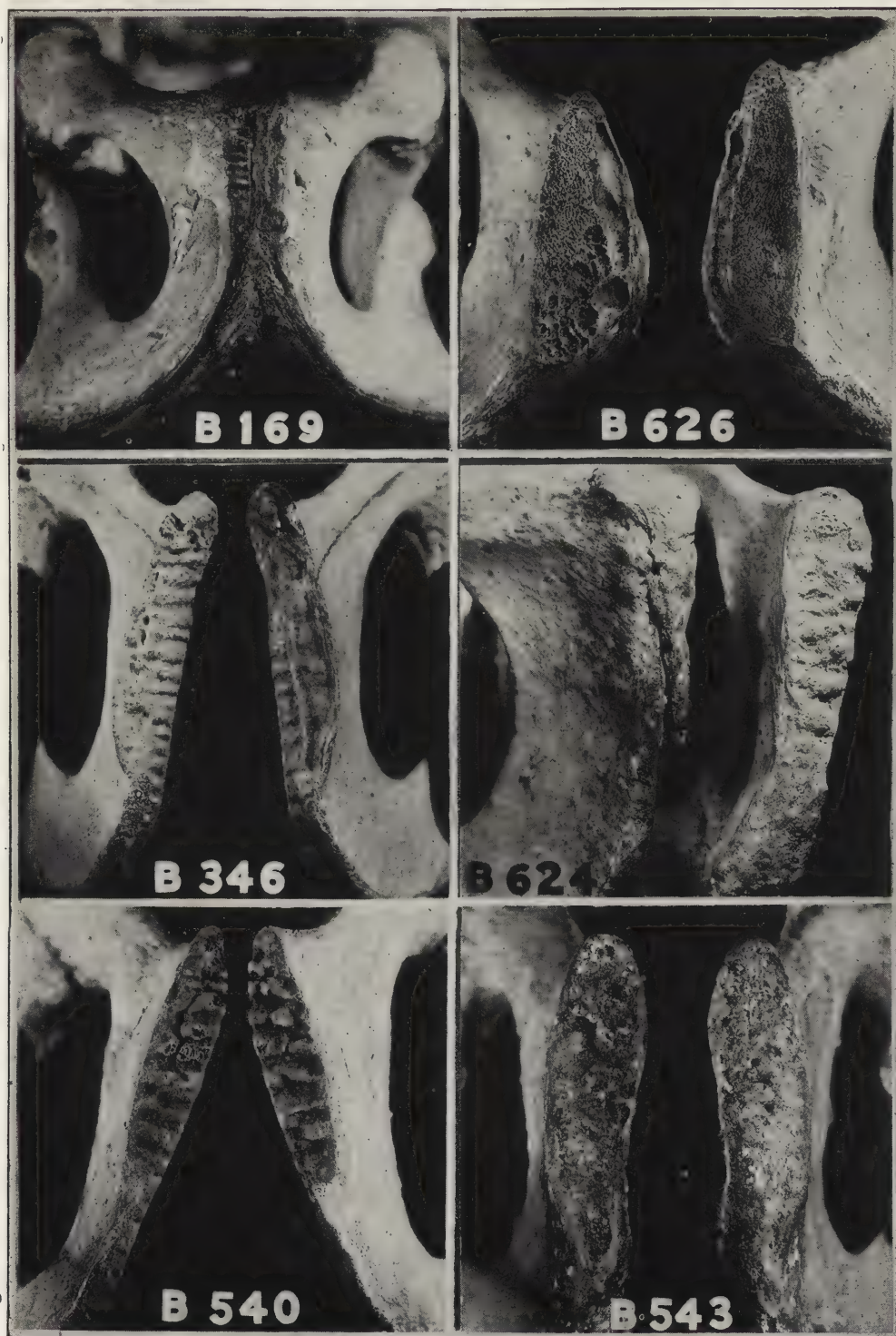


PLATE VII

Top row, Figs. 33, 34.  
 Middle row, Figs. 35, 36.  
 Lowest row, Figs. 37, 38.



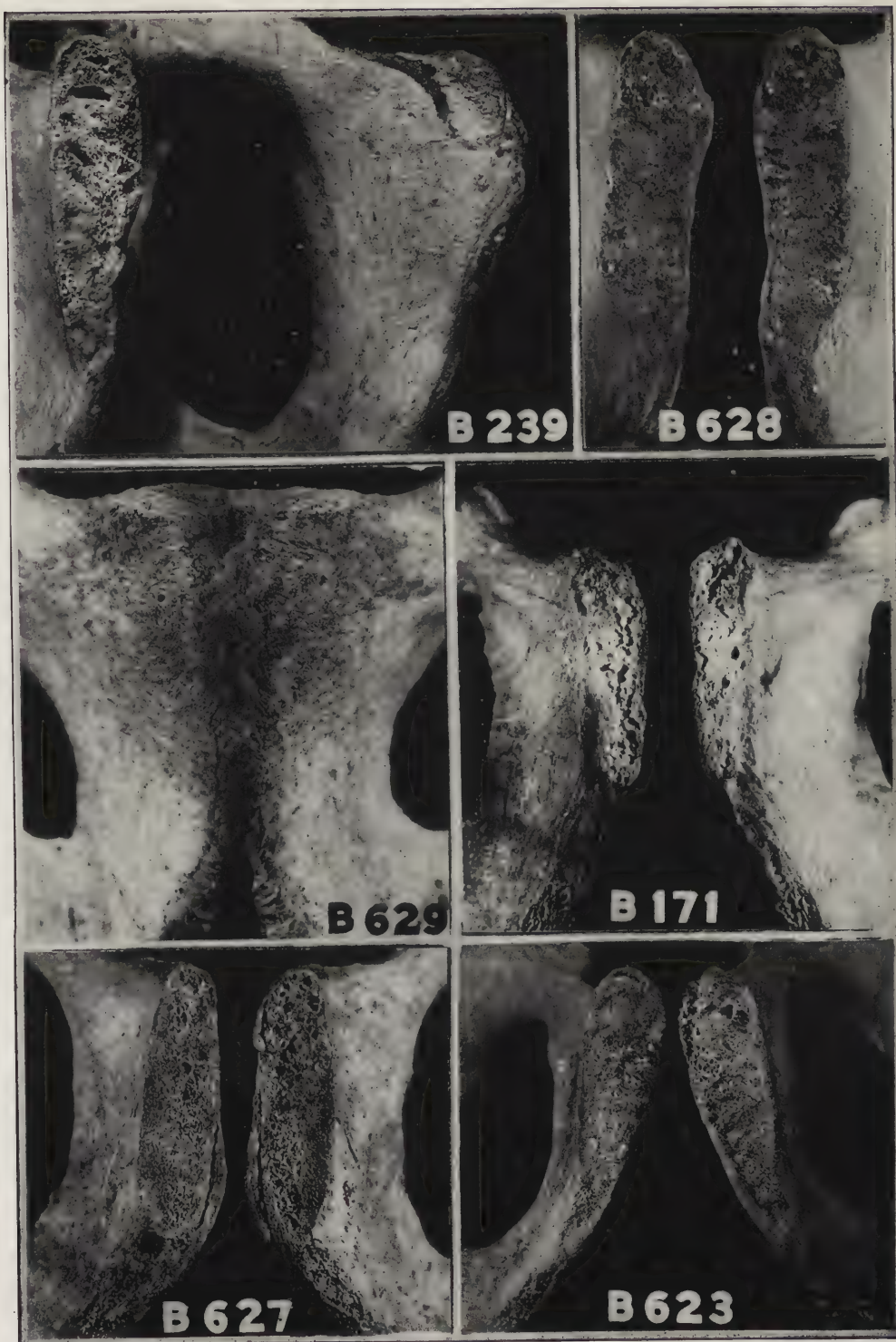


PLATE VIII

Top row, Figs. 39, 40.

Middle row, Figs. 41, 42.

Lowest row, Figs. 43, 44.



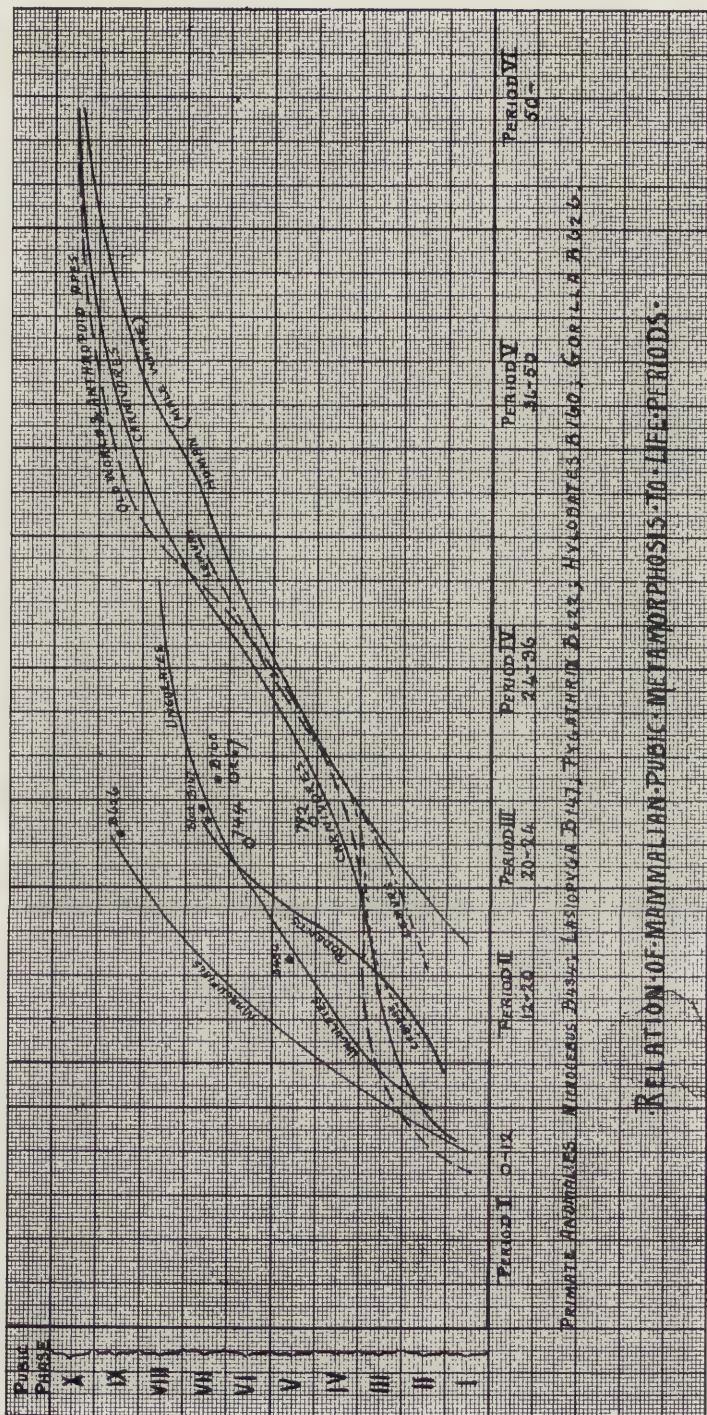


FIG. 45



## PLATE V.

- FIG. 20. *Canis familiaris* B 96. Nat. size. Note ischio-pubic symphysis.  
FIG. 21. *Canis familiaris* B 111. Nat. size. Fusion now involving pubis.  
FIG. 22. *Canis familiaris* B 110. Nat. size. Note fused lower nodule. The ischia do not actually fuse together but are united through this nodule.  
FIG. 23. *Canis familiaris* B 128. Nat. size. Completion of fusion. Note lack of union upper extremity and junction of upper and middle thirds of ventral margin.  
FIG. 24. *Canis familiaris* B 224. Nat. size. Ischia and lower nodule completely fused; pubic portions not yet fused.  
FIG. 25. *Canis familiaris* B 403. Nat. size. Secondary senile breaking down of ventral area.

## PLATE VI.

- FIG. 26. *Microcebus murinus* B 434. Five times nat. size. Note bilateral upper and lower nodules not yet fused.  
FIG. 27. *Pithecus nemestrinus* B 337. Nat. size. Note distinction between true symphyseal face and "extension" which is a secondary approximation of ischia.  
FIG. 28. *Lemur* sp. B 138. Three times nat. size. Typical pubic symphyseal face in phase II.  
FIG. 29. *Lemur variegatus* B 344. Nat. size. Note large upper and smaller lower nodules already fused. Ventral margin forming. No fusion as yet between the two sides of the pelvis.  
FIG. 30. *Hylobates hoo'ock* B 159. Nat. size. Phase II. Compare this with Fig. 29 and note area afterward occupied by upper nodule. Note approximation of ischia.  
FIG. 31. *Lasiopyga mona* B 147. Nat. size. Phase VII. Fusion of ischia by secondary approximation.  
FIG. 32. *Hylobates concolor* B 161. Nat. size. Phase VII+. Note approximation of ischia.

## PLATE VIII.

- FIG. 33. *Gorilla* sp. B 169. Nat. size. Quite young animal. Symphyseal ridges and furrows. Phase I.  
FIG. 34. *Gorilla* sp. B 626. Nat. size. Female: aberrant.  
FIG. 35. *Pan* sp. B. 346. Nat. size. Phase III.  
FIG. 36. *Gorilla* sp. B 624. Nat. size. Phase VI. Note median bar with no expanded lower nodule.  
FIG. 37. *Pan* sp. B 540. Nat. size. Phase III. Note "extension" of symphyseal face along ramus.  
FIG. 38. *Pan* sp. B 543. Nat. size. Note completion of symphyseal outline without intervention of median bar.

## PLATE VIII.

- FIG. 39. *Gorilla* sp. B 239. Nat. size. Commencing fusion of two pelvic halves broken in maceration. Left shown in face: right in ventral aspect.



- FIG. 40. *Pan* sp. B 628. Nat. size. Typical phase VIII. No fusion.
- FIG. 41. *Pan* sp. B 629. Nat. size. Typical phase VII+, with fusion. Contrast Fig. 40.
- FIG. 42. *Pan* sp. B 171. Nat. size. Typical phase X. No fusion.
- FIG. 43. *Gorilla* sp. B 627. Nat. size. Phase VIII supervening. Note large ridge (Cleland) for *M. gracilis*.
- FIG. 44. *Pongo pygmaeus* B 623. Nat. size. Typical phase VI. No fusion.
- FIG. 45. Graph of relation of pubic metamorphosis to age. (See text, especially p. 398.)

## AGE CHANGES IN THE PUBIC BONE

### VI. THE INTERPRETATION OF VARIATIONS IN THE SYMPHYSIAL AREA

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#### INTRODUCTION

At various stages in the demonstration of features characteristic of pubic metamorphosis, both in Man and in mammals generally, it has been necessary to call attention to the occurrence of variations from what I have defined as the normal. In the earlier part of the investigation before what one may term the typical manner of pubic metamorphosis and the normal order of sequence of its successive phases had become crystallized into definite form the number and variety of the variations themselves proved a constant source of discouragement and confusion. The disturbance which they repeatedly caused in the routine examination of specimens, the ever-recurring necessity of reverting to specimens already examined and recorded because of the doubt cast upon interpretation of observations by the appearance of another anomaly or variation, the delay of confidence in the final results occasioned by them, distressing as they all were, nevertheless ultimately gave point and assurance to the scheme finally evolved. This scheme

has been presented in former parts of this memoir. When I published the account of metamorphosis as illustrated by the male White pubis I drew attention to the occurrence of anomalies regarding both manner of pubic metamorphosis and time relationship (4 p. 315), but admitted that at that time no very clear explanation of the factors controlling pubic metamorphosis in either type or time had as yet presented itself to me. Further investigation was plainly necessary.

When I came to present the evidence for the male Negro-hybrid material I showed (5 p. 23) that anomalies in time relationship of pubic metamorphosis, whether of acceleration or of retardation, may in some cases be but one feature of a general anomalous time relationship common to the entire skeleton. I also showed that in certain instances the time anomaly was confined to the symphyseal area. A third type of cases occurs in which there are contradictory indications of skeletal age in the different parts of the skeleton. This was the natural development of the argument as originally foreshadowed in part I of the memoir. Further on I showed (5 pp. 36, 46) that the same anomalies in point of time present themselves in female pelves of both White and Negro-hybrid Stocks. Scattered references to anomalies of shape are to be found in the discussions of both Stocks (4 p. 315; 5 pp. 61-63), but so far variation seemed to fall under the headings of time relationship and morphological shape only. As a matter of fact this was not the case. The importance of reviewing with equal care our mammalian material had already been impressed upon my mind by the occurrence of variations in actual building of the symphyseal outline. It appeared that these could be accounted for only after the conditions in at least the Anthropoids had been noted and viewed in the light of human metamorphosis. I therefore carefully refrained from bringing these cases into prominence until the whole evidence could be produced. To have brought them forward before would have been to cause confusion in the mind of the reader, comparable with that induced by these specimens in my own mind, without at the same time being able to supply the corrective of the more complete knowledge which living in the midst of the material permitted. Nevertheless I drew attention briefly to the variation in manner of building up the symphyseal outline in the discussion of phases IV, V, VI (4 pp. 306-308; 5 pp. 8-10).

The fact that pubic metamorphosis in the giant Anthropoids may follow one of two courses, especially in light of the typical Eutherian metamorphosis (6 pp. 388, 400) clearly gives the clue to the variation of human metamorphosis in respect of symphyseal outline. This will therefore be one of our chief concerns in the present paper.



## HISTORICAL REVIEW

As regards previous observations on variation of the symphysial region in Man there is little to record. It is however profitable to refer briefly to the work by Aeby upon this subject (1).

In horizontal sections through the symphysis pubis Aeby noted the asymmetry of the symphysial faces especially at the ventral margin. He suggests that description of these variations would be useless and unprofitable since they are governed by chance and not by rule. Aeby drew this conclusion because he saw the symphysis only in section. Had he been able to examine the entire symphysial face it is probable that he would have recognized an underlying plan in the building up of the ventral margin.

Aeby refers to the description by Gurtt of complete or incomplete union at the symphysis pubis, the result of inflammatory reaction. This corresponds to our specimen No. 339 which has already been described (5 p. 59).

The effect of age and sex upon pubic metamorphosis cannot be included with our present knowledge under the heading of variations as Aeby included it. The fundamental importance of these factors in pubic metamorphosis has been sufficiently emphasized in previous sections of this work.

The three variations in shape of the symphysial face noted by Aeby have been fully set forth (5 pp. 61-63) and it is unnecessary to do more than recall them. They are extreme vertical shortness of the symphysial face, unequal height of the right and left faces, and difference in the sagittal curve of the surface, one face being convex in this direction and the other concave. We shall learn a little further on that these three variations are all phases of one type of anomaly.

The fact that the bony outline of the symphysial face is formed of cancellous tissue in the young but covered by a compact shell in later years, as noted by Aeby (1 p. 10) cannot fall within the category of variations. This is a normal change which must occur in any bony surface on which there is even the slightest mobility of an adjoining tissue. It takes place in all cases of non-union of fractures and at the plane of demarcation between the two ossifications in such cases as *os acromiale*. Further discussion of this example of a general law of bone metamorphosis is unnecessary at this juncture.

## TYPES AND RANGE OF VARIATION

In previous statements relating to symphysial variations age relationship and shape have been dwelt upon but as pointed out in the

introduction there is an equally important variation in type of the detail of metamorphosis which has been noted it is true but not clearly differentiated.

Again we have observed variation in age relationship at least in the Primates as well as in Man. These instances are recorded in Part V and are shown in the chart of age relationships which is reproduced once again in this article as Fig. 1.

We may then regard variations of the symphyseal region as separable into three classes:

Variations in type of metamorphosis.

Variations in age relationship of metamorphosis.

Variations in physical form of the symphyseal face.

No doubt examples of each of these classes could be identified throughout all mammalian orders had one sufficient material to draw upon. Here however we shall confine ourselves to Man and the Primates. Some examples would fall equally appropriately into more than one of the above classes.

#### VARIATIONS IN TYPE OF SYMPHYSEAL METAMORPHOSIS. THE VENTRAL RAMPART

There could be no better method of introducing the difference in type of symphyseal metamorphosis than by calling attention to the several features of Figs. 2 and 3. Fig. 2 illustrates the symphyseal area of No. 238, male, White, age 30. Fig. 3 portrays the same parts in No. 342, male, White, age 34. Both symphyses are in the same phase, namely VI for each shows the formation of a ventral margin but there is an essential difference between them. Whereas in No. 238 the ventral margin is growing by the gradual accretion of new bone to the site of the future margin, in No. 342 there is a definite rampart in course of development. This has been produced, as stated in previous sections of the work, by the extension of ossification from the upper and lower nodules aided by the appearance of independent ossicles along the line of the future ventral margin. In course of the formation of the ventral margin actual bony bridges are formed and under two of these on the left side pins have been thrust to demonstrate the fact that these are really bridges. It is the reason for the difference between these two types of metamorphosis that we are to investigate. As a matter of fact the type of No. 248 is much more common among examples of the White stock but the other type is by no means rare. All that one would say is that it is not so frequent as the second type.

In the description of the male White os pubis no marked distinction was drawn between these two types and both are well represented in Part I Plate III, which shows phase VI as found in the male White pubis. Indeed there are all manner of intermediate forms between extremes of the two types. One source of confusion at first was the tendency of those specimens possessing a well marked rampart in process of formation to be precocious. The ventral rampart, if it occurs, is very apt to form earlier than does the ventral margin in those cases in which the margin grows by simple accretion. At the moment however I desire to differentiate between the time relationship as such and the mode of formation of the ventral margin, leaving the former for discussion under the heading of variations in age relationship of metamorphosis.

A very striking example of rampart formation before the process is so far advanced as in Fig. 3 is shown in Fig. 4. This is a photograph from No. 764, male, Negro-hybrid, age 25. Again we dismiss the age relationship for the present. The extension of ossification from the extremities is clearly seen and there are independent ossifications along the line of the future rampart, already fusing with the symphyseal face.

Figs. 5, 6, 7. represent the condition of the ventral rampart after its fusion with the symphyseal face is complete.

Fig. 5 is from No. 635, male, White, age 32.

Fig. 6 is from No. 305, male, White, age 35.

Fig. 7 is from No. 459, male, White, age 50.

In these specimens there is no doubt whatever that the ventral margin has been formed by a rampart.

For an explanation of the occurrence of the ventral rampart we turn to Figs. 8 and 9 which are symphyseal face and ventral views respectively of No. 774, male, Negro-hybrid, age 22. As seen in Fig. 8 the ventral rampart is already completely formed and fused throughout with the symphyseal face which is still no further advanced than late phase II. The unusual character of this specimen has previously been commented upon (5 p. 17) but it remains now to emphasize its fundamental importance in interpretation of the ventral rampart. Fig. 9 shows how enormous is the upper nodule which extends outward to include the pubic tubercle. The size and shape of this upper nodule recall the features of the upper nodule in other Primates. In this regard the reader should compare this figure with Figs. 29 and 30 in Part V. The continuity of the ventral rampart with the epiphyseal ossification along the ischio-pubic ramus is also very clearly seen in spite of the constriction just beneath the symphyseal face. From this one would infer that



upper and lower nodule together with the ventral rampart are all morphologically comparable with the ischial epiphysis. They are certainly developed from ossific centers making their appearance in a single morphological plane. The ventral rampart and the extremities may therefore be regarded as epiphysial formations but when we begin to inquire further what is the nature of these epiphysial formations and what they are doing in this situation we launch ourselves upon a larger problem which must be postponed until a later page.

Undoubtedly the ventral rampart and extremities are epiphysial in nature and this explains why in their more perfect condition they tend to develop earlier than is typical of the phases with which they are respectively linked.

If this proposition is true, and there seems no valid reason to reject it, the ventral margin which develops by simple accretion of bony tissue is a retrogressive type of epiphysial formation. Also it follows that the more retrogressive it is the more tendency is there for it not to form at all. Now we have seen that quite frequently there is failure of the ventral margin to develop at the junction of its upper and middle thirds, and often the upper third including the upper nodule fails altogether to appear. All this is quite consistent and hangs together when it is correctly interpreted but if the connecting thread which runs through the entire series of variations has not been grasped and held securely there appears to be nothing but an unwieldy and chaotic mass of variations for which there is no significance.

Now let us pass one stage further and examine the nature of these epiphysial formations. It would be rather natural to regard a non-uniting symphysis with bilateral epiphysial centers of ossification as more primitive than a symphysis which fuses and presents a single median ossification, the median bar. That is to say one would be inclined to regard the human symphysis as more primitive than the fusing type of Anthropoid symphysis represented by Figs. 36 and 41 in Part V. From the history of the Eutherian symphysis as elucidated in Part V (6) we know that this is not the case. The human symphysis presents a reversion in its nonfusing character. And since the median bar is lost as such we must infer that the bilateral epiphysial ossification centers, from which develop the ventral margin and the extremities, represent this median bar once again resolved into its constituent parts. For, of course, it may be surmised that although the median bar is a single mass it ossifies from bilateral centers which quickly fuse in the more typical Eutherian mammal. For a full consideration of the principles

upon which this argument is built up one must refer the reader to the extended account of the mammalian symphyseal area in Part V.

#### THE LOWER EXTREMITY

We have just noted that the ventral rampart and the extremities of the symphyseal face are all epiphyseal formations possessing a definite and important phylogenetic history. Our attention so far has been concentrated upon the ventral rampart. We must now examine the lower extremity in greater detail.

Figs. 10 and 11 show face and ventral views of No. 792, male, Negro-hybrid, age 23. No ventral rampart or margin has yet appeared. The shell of tissue which will form the upper nodule has not developed. But the lower extremity is present and is especially marked on the right side as shown by Fig. 10. The definite relationship of this lower extremity to the epiphysis of the ischio-pubic ramus is plainly demonstrated.

Figs. 12 and 13 illustrate the same point. They are corresponding views from No. 524, male, Negro-hybrid, age 24. The difference between this specimen and the last is that in this the epiphyseal extension which forms the lower extremity is relatively greatly increased in size. Also the connection with the epiphysis is not nearly so clearly seen. The question as to whether the lower extremity is actually increased in this case or is relatively decreased in the last will be for the ensuing evidence to decide.

We have learned from Part V that the Primate symphysis probably early differentiated off from the typical Eutherian condition and that the main feature of this differentiation was the reduction in extent of the symphysis so that it became confined to the os pubis and probably not to the full length of that. In this process the lower nodule so typical of the generalized Eutherian symphysis was lost. It is not quite clear as to what happened to this nodule. That it was originally bilateral in nature is apparent and that it may readily revert sufficiently to retain for a long period the evidence of its bilateral nature is clear from Part V Plate III. Possibly it was lost altogether with the shortening of the symphysis, but it is probably safer to surmise simply that it disappeared as an entity and that the ordinary epiphyseal formation along the ischio-pubic ramus took its place. In any event this epiphysis crept along the ramus until it encroached upon the os pubis and thus we find the lower extremity of all Primate symphyseal faces completed by this epiphysis.

## THE UPPER EXTREMITY

The upper extremity of the symphysial face differs from the lower extremity in that it is much more erratic in the form of its development. In the later years of the second decade of life there may appear a bony nodule of epiphysial nature in the site afterward occupied by the upper extremity. In the early twenties this nodule fuses with the symphysial face but does not typically take on any marked growth until later in the third decade after the commencing delimitation of the lower extremity. But the method of formation of the upper extremity is exceedingly variable. Sometimes a very large nodule occurs, and when this happens the nodule is likely to proceed to form the upper extremity unusually early. In other cases there is no nodule formed but the upper extremity develops simply from accretion of bony tissue like the ventral margin. Again the upper extremity may never form at all. Such cases are more liable to occur in White than in Negroid stock.

Figs. 14 and 15 illustrate the large nodule. They are from No. 413, male, Negro-hybrid, age 22. The erratic nature of the nodule and its want of relationship to any other feature of the symphysial face are quite apparent in Fig. 14. In Fig. 15 the connection of the nodule with the epiphysial formations along the ischio-pubic ramus would never be suspected were it not for the preceding figures.

The problem of how to interpret the upper nodule when it occurs is not a difficult one. We have seen that the lower nodule was early lost in the Primate symphysis. This is the probable reason for never finding a corresponding large mass at the lower extremity of the symphysial face. The upper nodule like the ventral rampart represents a typical Eutherian structure. As the median bar becomes resolved into its bilateral elements so the upper nodule loses its single character and reverts to a bilateral structure. But whereas the loss of the lower nodule is characteristically a Primate feature the upper nodule tends to disappear in many orders. Thus in Carnivores, in Ungulates and in Rodents there is frequently absence of the upper nodule with consequent incomplete formation of the upper part of the symphysial area. In Man this incompleteness of formation is more characteristic of White than of Negro-hybrid stock.

Because of tendency to diminution or loss of the upper nodule there is an uncertainty about the time of its appearance or, what is the same in principle, irregularity in age relationship of the delimitation of the upper symphysial extremity. Hence the definition of the upper



extremity becomes a feature of symphyseal metamorphosis upon which no great confidence can be placed as regards age.

In the typical Eutherian mammal the lower nodule ossifies before the upper. But in the Primate the lower nodule is lost, nevertheless the lower extremity also typically commences to become defined first. The new character of the lower extremity together with the irregular nature of the upper nodule in its retrogression have somewhat confused the time relationships of delimitation of these two features. It is really surprising that they should be as reliable in relation to time as they actually are.

From the foregoing description we see that the only really permanent and constant features of the symphyseal face throughout the mammalian class are the dorsal margin and adjacent dorsal platform. One may therefore understand why these features present the most constant age relationships in pubic metamorphosis.

#### VARIATIONS IN PRIMATE METAMORPHOSIS

It may be the result of the relatively few observations upon the various orders of mammals compared with the large number possible upon Man that there seems to be a fair uniformity in type of symphyseal metamorphosis within each order. Yet in the body of Part V sufficient indication exists of differences in the orders Primates and Rodentia at least. The important consideration for explanation of these differences is the fact that in both of these orders the symphyseal area is undergoing retrogressive changes

So far as the Marsupials and the Carnivores are concerned the type of symphyseal metamorphosis is remarkably uniform. In these animals the symphyseal area probably closely resembles the primitive Eutherian type. In all Insectivora except the Menotyphla the symphyseal area is so specialized that the symphysis is either rudimentary or lost and therefore does not present itself for consideration. The Edentates again present a very specialized symphysis regarding which we have not enough evidence to form more than a speculative notion of its construction. It must also therefore be omitted from consideration. The symphysis of the Ungulates is peculiarly specialized and of no immediate service. Again, so far as the Artiodactyla and the Perissodactyla are concerned the type is practically uniform.

Among the Rodentia we meet with every type of symphysis from the typical Eutherian form represented by *Castor* and *Dolichotis* to complete absence of the symphysis as in certain species of *Microtus*. Interme-

diate in position is the Guinea-pig if the statement of Flower (3) that fusion does not occur at its symphysis be confirmed. If this is the case the Guinea-pig symphysis is in very much the same position as that of Man. We owe much to the work of Chapman (2) for information upon the really intermediate forms. In the Pocket Gophers (*Geomys*) and some few other Rodents some individuals possess a symphysis while others do not. Chapman found that all male specimens of *Geomys* have a "closed" pelvis whereas some females, but not all, have an "open" one. By this term it is meant that the two halves of the pelvis do not meet at a symphysis. The author states that he found no intermediate forms; either the bones met at the symphysis or the symphysis was entirely absent. From our point of view however the male specimens of *Geomys* (see Chapman's Fig. 4) are the real intermediate form, for in them the symphysis is reduced to an exceedingly small area. In spite of these marked differences in the Rodent symphysis we have not sufficient information upon the method of metamorphosis to deal in detail with variations in metamorphosis in the Rodentia although it is perfectly clear that the precise mode of formation must differ between, let us say, *Dolichotis* and *Microtus*.

There remains then the Primate symphysis for consideration. No distinction in type of metamorphosis is noted except the peculiarity shown by the *Cercopithecidae* (and *Hylobates*) in secondary approximation of the ischia, and the two forms of symphysial formation found in the giant Anthropoids.

As regards secondary approximation of the ischia it has already been pointed out (6 pp. 376, 385, 392) that the involvement is a feature developing during post-natal life. It is so specialized a character that we need not refer further to it here.

The really important variation in metamorphosis among Primates is the difference in type among the giant Anthropoids. We find on the one hand a form of metamorphosis very similar to that typical of Man, and on the other a form which brings these animals into line with other and more typical Eutheria. The differences have been discussed in Part V. It now remains to associate them in their proper phylogenetic position. The more generalized form typified by *Gorilla* sp. B 624, Fig. 36 in Part V shows a median bar with large upper median nodule but no lower nodule. This last feature is explained by the loss of the lower nodule early in Primate evolution. This form of metamorphosis is exactly that shown by other Primates. From the study of such specimens as *Microcebus* B 434 it is apparent that both upper nodule

and median bar are formed from the union of bilateral centers of ossification. Sometimes as in *Gorilla* sp. B 239 (Part V, Plate 8, Fig. 39) the median bar is very short and on fusion of the symphyseal area all trace of it is lost. It may be that this is what has happened in *Pan* B 629 (Part V, Fig. 41). But in many instances no symphyseal fusion occurs and the symphyseal outline is built up precisely as in Man. In these cases there is no ventral rampart but the ventral margin is formed by simple accretion.

One can explain these two forms of metamorphosis only upon the ground that the second is more retrogressive or at least more specialized than the first. We have not so far seen any Anthropoid symphysis in which there is formed a ventral rampart such as occurs in Man but even in Man it is comparatively rarely that one finds plain indications of this, such as are figured in this article (Plate II). We possess only some twenty-five skeletons of giant Anthropoids but nearly eight hundred human skeletons. It is natural therefore that the range of variation in the Anthropoid pelves should not be so great or complete as in the human series. The second type of Anthropoid symphysis is unmistakably the same as the typical human form. The development of a ventral rampart in the human symphysis is equally clearly an effort to reproduce as closely as possible the first type of Anthropoid symphysis in which there develops a median bar.

#### VARIATIONS IN HUMAN AGE RELATIONSHIP

The previous sections have shown how intimately related to type of metamorphosis are the time relations of the several features. We have noted that the human symphyseal area is very different from the typical Eutherian area and is somewhat retrogressive. The oldest and least changed part is the dorsal margin and the surface immediately adjacent. These preserve the most constant time relations. Ventral rampart or margin and lower extremity are considerably changed and show therefore some variation in time relation especially marked in cases like No. 744 where the "epiphyseal" nature is particularly well retained. In such instances the character of the dorsal margin and area will prevent one being misled by the early appearance of the other features.

On the chart of mammalian age relationships (Fig. 1) I have marked with open circles the position of three of the more marked variations from the human normal, namely Nos. 267, 744 and 792. These are all examples of acceleration and like the corresponding examples of acceleration among other Primates they fall within or quite close to the range of Placental mammals.



The delay in commencement of pubic metamorphosis in Man is the only point in which he differs from other Primates and the fairly generalized (so far as their symphysial region is concerned) Carnivores. There is at present no explanation of this except the quite vague one of lengthening out of childhood. The delay characterising human metamorphosis in the seventh and eighth phases may be more apparent than real. It may arise from the errors consequent upon the necessity of comparing a fused type of symphysis with one in which union does not occur. At least it is interesting and it is also quite significant that during phases IV, V and VI, namely the period of development of the ventral margin and extremities the curve of human metamorphosis should most closely follow that of other Primates. This fact materially strengthens the probability that the general interpretation of human pubic metamorphosis herein put forward is correct.

A series of photographs are presented to illustrate the precocity induced by retention of the ventral rampart. Figs. 16 and 17 are taken from No. 267, male, White, age 25. In them one sees the same features which are already recorded in No. 744 but much less clearly. Comparison of the two sets of photographs will at once demonstrate the similarity. Fig. 18 is from No. 495, female Negro-hybrid, age 25. Here again it is obvious that the development of a ventral rampart has resulted in unusually early completion of the symphysial outline.

A less marked precocity with probably some stagnation of metamorphosis is exhibited in Fig. 19. This represents No. 360, male, White, age 30. The formation of the ventral rampart though incomplete has apparently ceased and the filming over of the cancellous tissue of the symphysial face by a compact shell has also ceased.

This cessation of metamorphosis is still more distinctly shown in Figs. 20 and 21. These are from Nos. 307 and 210, male, White *cadavera* thirty-six and forty-eight years of age respectively. In spite of the occurrence of an upper nodule in both and the beginning of a ventral rampart in No. 307 all metamorphosis seems to have stopped. With cessation of metamorphosis there comes a waxy appearance over the symphysial face. This appearance is quite characteristic and invariable. Its importance as a sign of non-activity will be constantly stressed in this series of investigations upon the skeleton.

#### VARIATIONS IN PRIMATE AGE RELATIONSHIP

We have seen in Part V that the same variations in time relationship are equally apparent in other Primates as in Man. The unusual pre-

cocity of our specimen of *Microcebus* B 434 has been remarked previously and there seems no legitimate reason for this acceleration. It does not appear that *Microcebus* should show much acceleration of metamorphosis over *Tarsius*. Yet because of the paucity of our material and the little known nature of both of these animals it is unprofitable to pursue this point further.

Again there seems at present no adequate reason for the acceleration of metamorphosis in the other examples shown on the chart (Fig. 1). These are *Lasiopyga* B 147, *Pygathrix* B 622, *Hylobates* B 160 and *Gorilla* B 626. In the *Gorilla* the acceleration cannot be set down to the type of symphyseal formation since no median bar is formed and no fusion takes place. The photograph (Part V, Fig. 34) shows marked vascularity of the symphyseal area but I have stated earlier in this memoir why one cannot accept Aeby's theory that such vascularity accelerates pubic metamorphosis.

A striking feature of the variation in age relationship in all Primates including Man is that when acceleration occurs it carries the time relationship no further than the bounds of the general Eutherian range. Likewise the retardations, which are not figured on the chart but may be found in the body of the memoir, only bring the individual mammalian symphysis closer in position on the chart to the curve for Man.

The subject of age relationship in the Mammalia generally has been touched upon several times before. At the moment I desire particularly to accentuate the intimate connection between acceleration of pubic metamorphosis, and phylogenetic history as indicated by variations in type of the metamorphosis itself.

#### VARIATIONS IN SHAPE OF THE SYMPHYSEAL FACE

We have now completed our survey of variations in type and in time relationship of metamorphosis but the series of observations would be incomplete were we to omit reference to variations in shape of the symphyseal face.

The normal shape of the symphyseal face in Man is very like that of other Eutheria in which marked specialization has not taken place. It is long and not very broad. Observations upon the relation of sex to the symphyseal shape are not in order at this juncture. In both sexes this elongated oval outline is quite characteristic but not invariable. In other mammals we have seen that as specialization towards reduction becomes more and more marked the symphyseal face shortens and broadens. In the *Artiodactyla* and the *Perissodactyla* the symphyseal

face presents an almost circular outline. We have learned that the human symphysis is specialized to a greater degree than that of any other Primate but by no means so far as the symphysis of many other Mammalia. We must expect therefore that anomalies of the human symphysis will occur which are further than usual from the typical Primate symphysis. These would be the antithesis of the variation in which a ventral rampart is formed. Since the human symphysis is plainly specialized towards reduction and separation of the constituent elements it is obvious that we must find anomalies in shape of the symphyseal face.

Fig. 22 shows the symphyseal face of No. 93, male, Negro-hybrid age 30. Instead of an elongated oval the face presents a rather reniform outline. This variety was very puzzling at first. It is not infrequent and it is always associated with acceleration in age relationship of metamorphosis. Actually however it is an early phase of the tendency to reduction in length and formation of a rounded symphyseal outline.

Fig. 23 is a photograph of No. 94, male, White, age 28. This time the extremely short and rounded symphyseal face is quite marked. Notwithstanding the smallness of the actual symphyseal articular area the original typical form of the symphysis still remains. Again there is acceleration in speed of metamorphosis. Both this and the foregoing specimen have been mentioned before (4 p. 315; 5 p. 63) but the essential significance of their shape could not be pointed out until after the evolution of the symphysis in the Mammalia had been presented.

Along with shortening of the symphysis there is also the tendency to failure of the pubic bones to meet in the middle line. We have noted that in *Galeopithecus*, *Gymnura* and other animals in which the symphysis is vestigial and the pubic surfaces do not meet the symphyseal faces are both rounded in outline and irregular in contour. Usually the contour of such specimens is convex, sometimes more so on one side than the other. We now turn to irregularities in contour as shown in human symphyses.

Fig. 24 shows the symphyseal faces of No. 226, female, Negro-hybrid, age 30. The elongated oval outline is still maintained although the symphyseal area is greatly reduced and metamorphosis has been accelerated. It is discussed in the section upon the female Negro-hybrid (5 p. 47). The left symphyseal face is convex in both directions whereas the right is concave.

This rare condition is again met with in No. 324, female, White, age 43. It is presented as Fig. 25. I have previously referred to it as a case of deformity (5 p. 33). Here the symphysis is not unduly shortened



and in consequence of the age one cannot discuss possible acceleration of metamorphosis. The right face again is concave and the left convex.

In continuation of the argument in the earlier paragraphs of this section we expect to find in some examples of the human symphyseal area evidence of specialization beyond that shown by the majority of specimens. It has been further shown that shortening with its associated acceleration of metamorphosis and irregularity of contour are related types of specialization not only in Man but in other mammals also.

#### RELATION OF SYMPHYSEAL VARIATION TO HUMAN STOCK

No attempt has been made in previous pages to indicate the percentage of different variations in the symphyseal region of Man. As a matter of fact this would be very difficult for there are fine gradations forming the intermediate stages between extreme conditions such as are figured in the present article. One could scarcely say where to draw any line of distinction between normal and abnormal.

Although there are many examples of relative short and broad symphysis in the reserve material the only strikingly variant specimens of this category are figured here. Similarly though there are numerous specimens which show evidence of a ventral rampart such as are presented here in Figs. 5, 6, 7, the sole examples in our collection which give clear and unmistakable proof of the morphological relationship of the ventral rampart are to be found in Plate II.

As to the frequency of these striking variations in different human stocks we have very little evidence. Actually they probably occur as often in the White as in the Negro-hybrid. Yet it is a fact that all the pronounced examples of ventral rampart occur in Negro-hybrids. In a former section of the memoir I have pointed out that the Negro-hybrid seems to differ from the White in that his symphyseal outline is always completed whereas in the White it is apt to be incomplete in the upper third of the ventral margin and the area of the upper extremity (5 p. 25). In these two respects the Negro-hybrid does, show in all probability, a tendency to retain a more typical Primate symphysis.

#### SUMMARY

##### THE SIGNIFICANCE OF VARIATIONS IN INTERPRETATION OF THE SYMPHYSEAL AREA

There is nothing new to add to what has already been stated in the foregoing pages. We have not considered all the varieties of the

symphysial region, human and mammalian, but we have taken note of those variations which, at this juncture in the investigation, plainly have some bearing upon the phylogeny and the present status of the human symphysis.

Variations in type of metamorphosis show the relation of the human symphysis to that of other Primates. Although no fusion ever occurs, except pathologically, and no median bar is ever formed in Man yet the ventral rampart and upper nodule clearly are derived from the Primate type of median bar.

The ventral rampart and the nodules, of the extremities, if they exist, are plainly epiphysial in nature but it is necessary to inquire further what is the nature of these ischio-pubic epiphyses. The answer to this query is given by the variations of symphysial metamorphosis themselves.

Variations in time relationship are closely related to variations in metamorphosis and, according to the type of metamorphosis, the variation in time relationship will bring the symphysial bone change into closer relationship with the typical Eutherian form or it will plainly show that there is a retrogression.

Variations in symphysial shape likewise fall into line with the other variations except that they naturally can only indicate the line of further retrogression which however is quite in harmony with the line which one would infer from a study of the mammalian symphysis in general.

As for any Stock-linked character in variations the evidence is not as yet very strong but there does seem to be some indication that the Negro-hybrid symphysis is apt to partake of a more typical Primate character.

Before ending this series of studies on the human and mammalian os pubis I desire to express my indebtedness to our prosecuting staff, Messrs Leonhart and Williams for the years of patient work in macerating and preparing skeletons by which such investigations as this are made possible. It is also fitting that I acknowledge to my colleague, Miss H. F. Harvey, my grateful appreciation of her tireless efforts and of the splendid results which she has achieved in this very special field of photography.

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## LEGENDS

FIG. 1. Chart to show age relationships of symphyseal metamorphosis in various orders of mammals including Man. The black dots represent Primate specimens showing acceleration. The black circles indicate the extreme position of specimens showing acceleration in Man. This is also reproduced as Fig. 45, Part V.

## PLATE I.

FIG. 2. No. 238, male, White, age 30. Usual type of human metamorphosis.

FIG. 3. No. 342, male, White, age 34. Formation of ventral rampart.

FIG. 4. No. 764, male, Negro-hybrid, age 25. An earlier stage of development of the ventral rampart.

FIG. 5. No. 635, male, White, age 32.

FIG. 6. No. 305, male, White, age 35.

FIG. 7. No. 459, male, White, age 40.

These three figures show the ventral rampart at various stages after completion.

## PLATE II.

FIGS. 8, 9. No. 744, male, Negro-hybrid, age 22.

FIGS. 10, 11. No. 792, male, Negro-hybrid, age 23.

FIGS. 12, 13. No. 524, male, Negro-hybrid, age 24.

These figures show symphyseal face and ventral views of three pelves which clearly indicate the nature of the ventral rampart and lower extremity.

## PLATE III.

FIGS. 14, 15. No. 413, male, Negro-hybrid, age 22.

These figures show how the upper extremity is related to the upper nodule characteristic of the Eutherian symphysis.

FIGS. 16, 17. No. 267, male, White, age 25.

FIG. 18. No. 495, female, Negro-hybrid, age 25.

FIG. 19. No. 360, male, White, age 30.

These four figures show how accelerated is metamorphosis when a ventral rampart develops.

## PLATE IV.

FIG. 20. No. 307, male, White, age 36.

FIG. 21. No. 210, male, White, age 48.

These figures show stagnation of metamorphosis. Note the characteristic waxy appearance of the symphyseal face.



FIG. 22. No. 93, male, Negro-hybrid, age 30.

FIG. 23. No. 94, male, White, age 28.

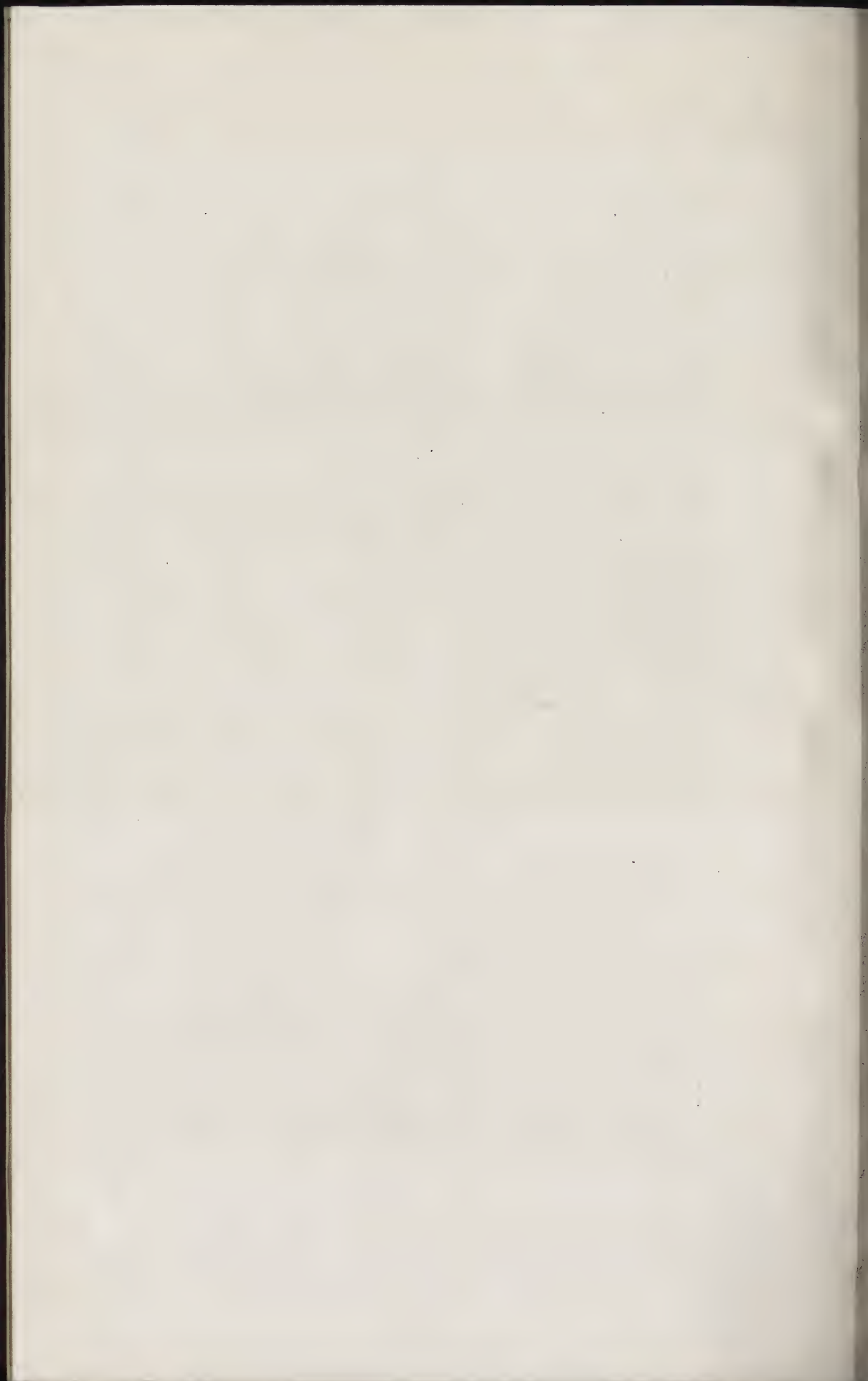
These two figures show reniform and short symphyses, both forms of the same process.

FIG. 24. No. 226, female, Negro-hybrid, age 30.

FIG. 25. No. 324, female, White, age 43.

These two figures show irregularity in contour of the symphysial faces, a deformity closely linked in origin with symphysial shortening.







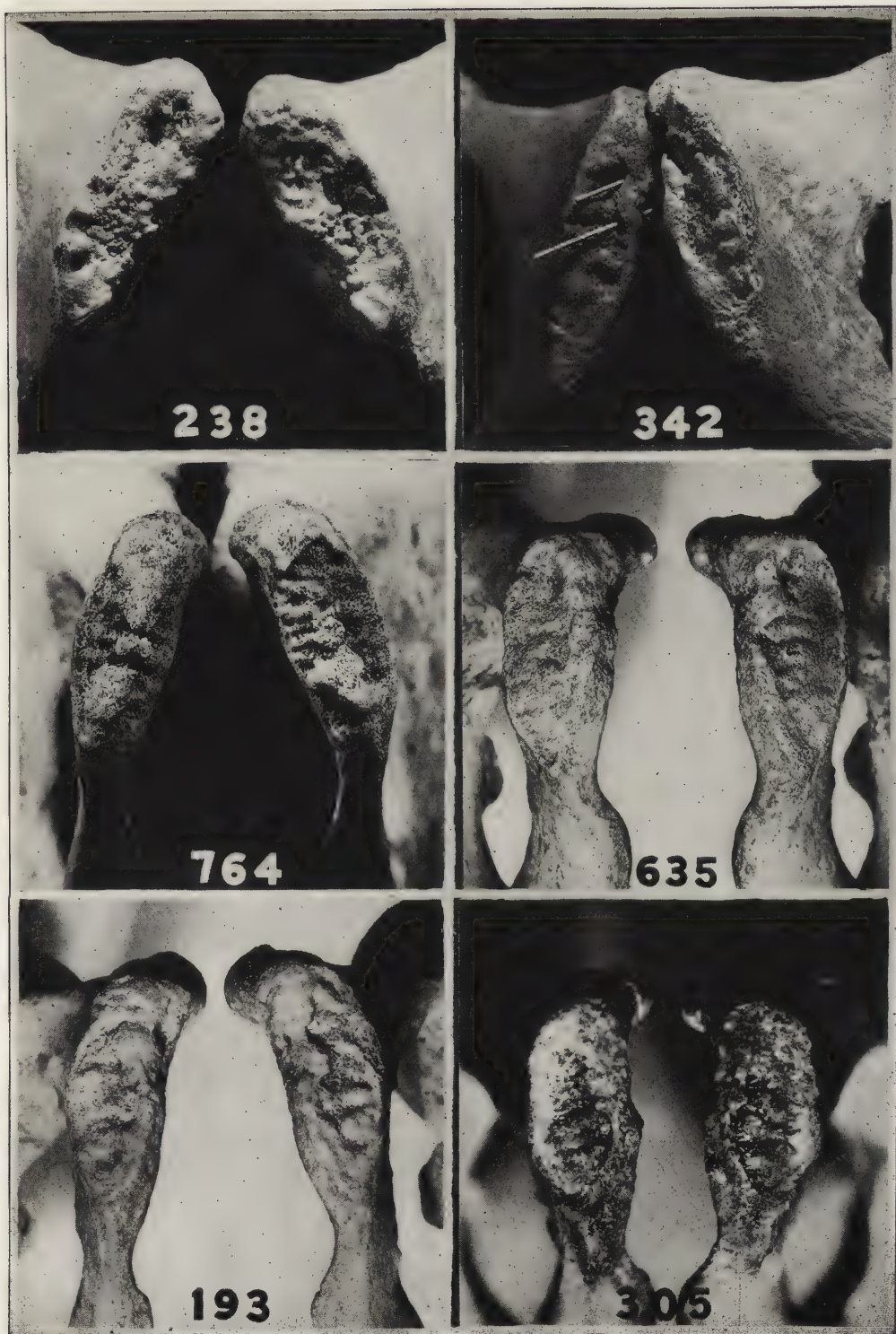


PLATE I

Top row, Figs. 2, 3.

Middle row, Figs. 4, 5.

Lowest row, Figs. 6, 7.



PLATE II

Top row, Figs. 8, 9.  
 Middle row, Figs. 10, 11.  
 Lowest row, Figs. 12, 13.



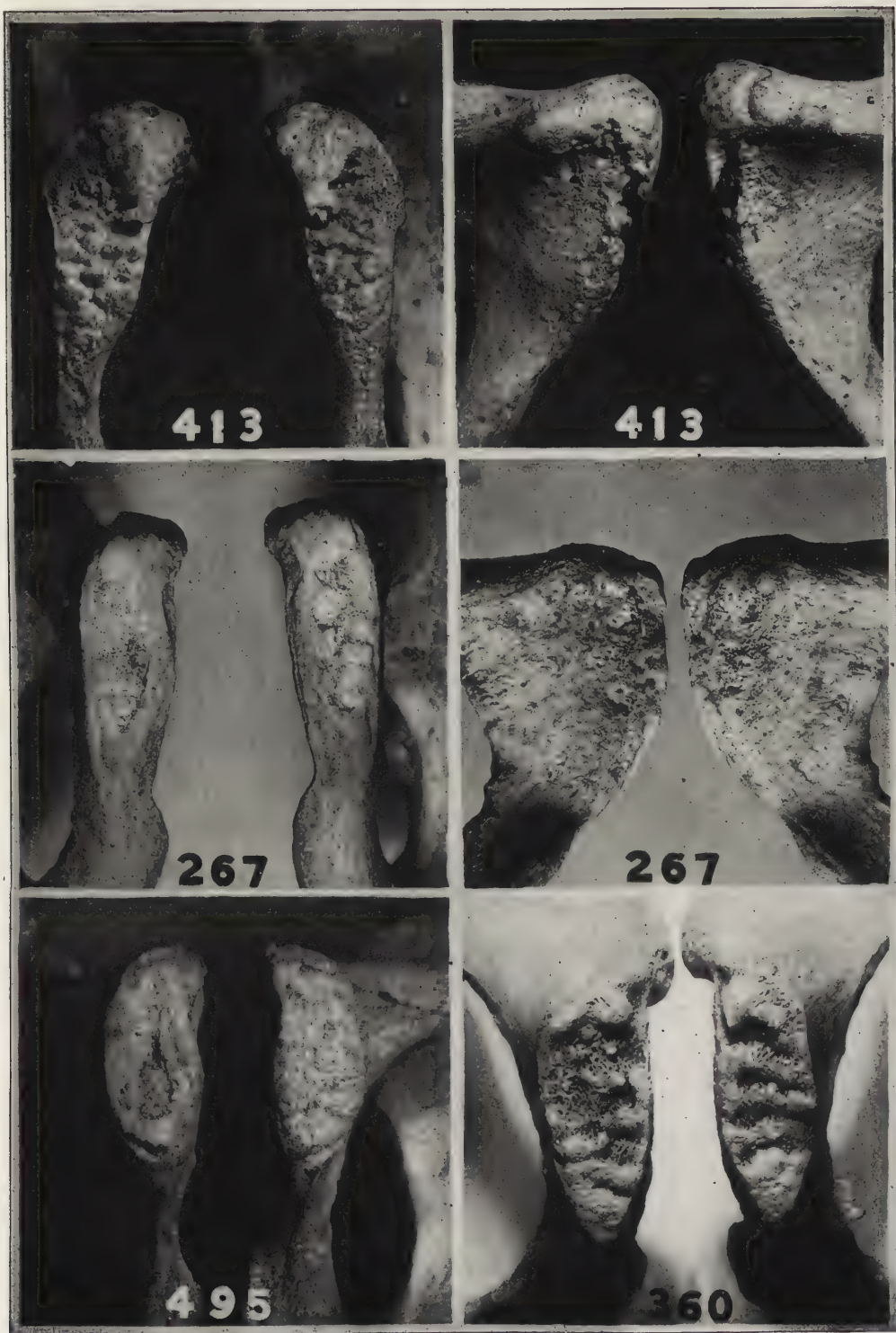


PLATE III

Top row, Figs. 14, 15.  
 Middle row, Figs. 16, 17.  
 Lowest row, Figs. 18, 19.



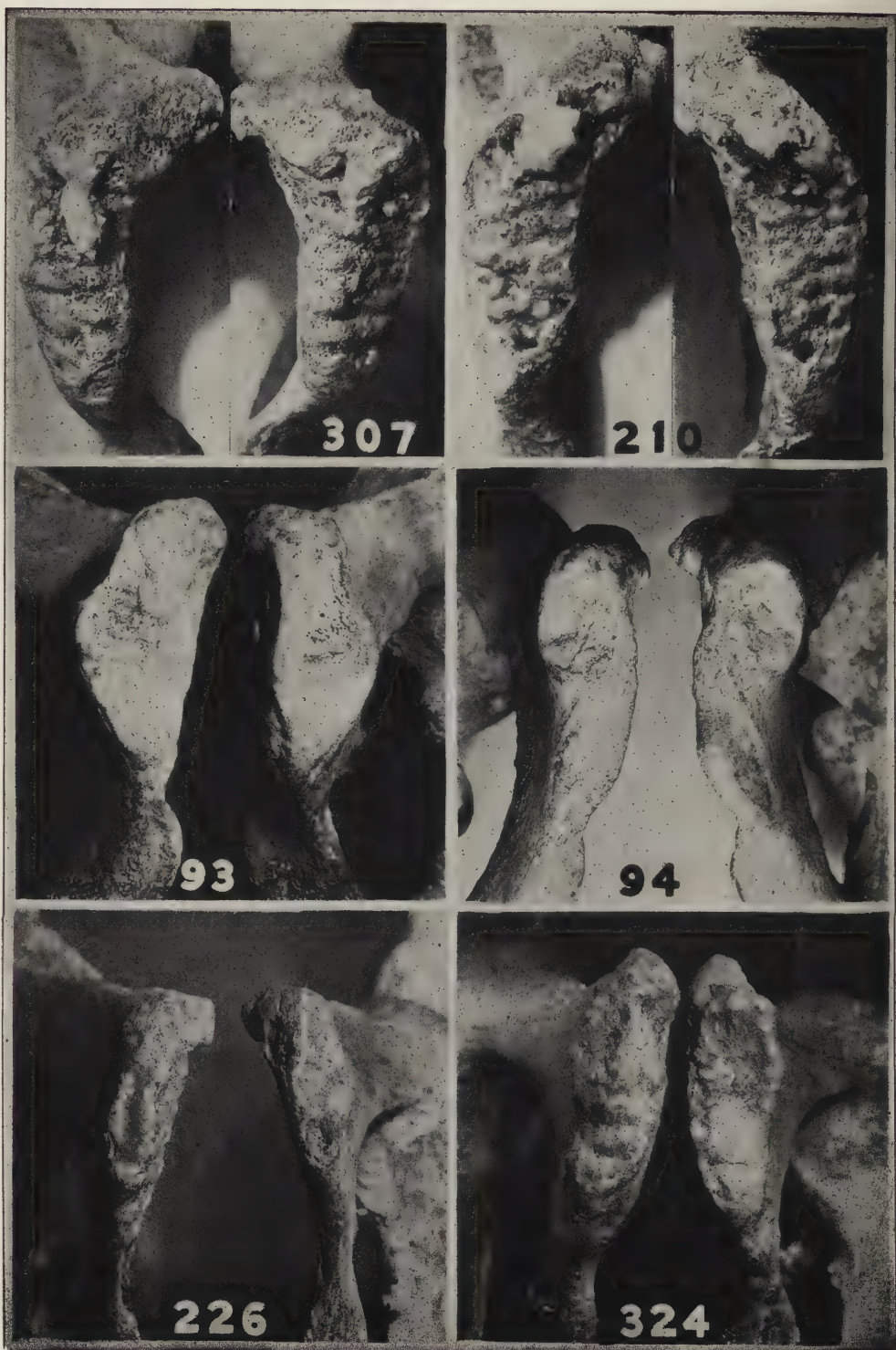


PLATE IV

Top row, Figs. 20, 21.

Middle row, Figs. 22, 23.

Lowest row, Figs. 24, 25.

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